











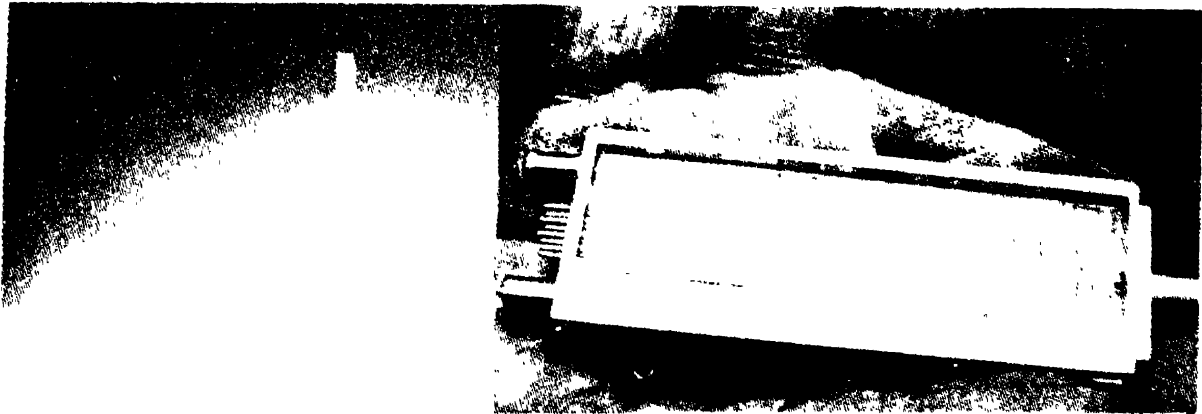


# SCIENCE REPORTER

JANUARY 1980



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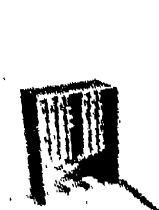
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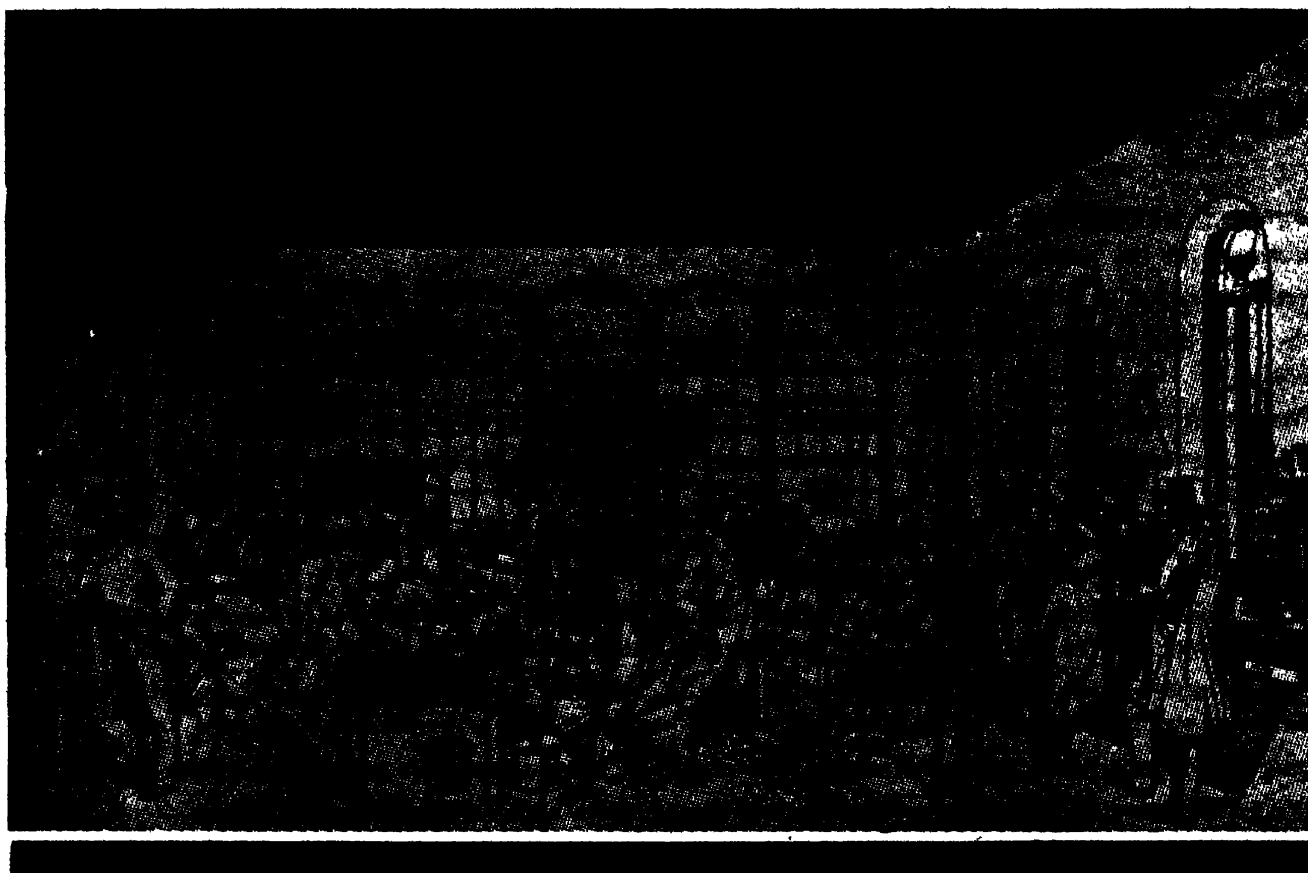
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### Jatinga bird mystery

Sir, In the article under reference (S.R., September 1979), some interesting points stated by the author themselves give a clue to the mystery. The phenomenon is observed only during the months of September-October, that is just after the cessation of the south-west monsoon over the area. In the day time, birds are scarce in the village and in the surrounding area. The birds flock at a fixed region, namely a width of about one km between the Jatinga railway station and the village Health Centre. Also, on the nights in question, the birds arrived within five to ten minutes of fixing the petromax lanterns. Particular groups dashed towards particular lights ignoring others. It is safe to assume that the flocks are part of migratory birds flying in the nights during the period (though there may be a few resident birds in the collection) and these, when caught in bad weather, simply drift with the strong winds. According to Kramer, navigational faculty is inhibited in birds, if neither the sun nor the stars are visible, as during periods of heavy overcast sky with rain or fog. Also, according to McLean and Williamson, migratory birds caught in strong winds and rain, become dis-oriented and begin to drift down-wind. Hence, the birds seen at Jatinga are birds in flight over the limited width, not at great heights, drifting down-wind having become dis-oriented due to the adverse weather and get attracted by the light of the petromax lanterns

which are directly in their line of sight. However, these suggestions are only tentative and require further investigation by experts.

#### Ref:

1. Kramer, G. (1952), Experiments in Bird Orientation, *Ibis* 94, pp. 265-85.
2. McLean, I. and Williamson, K. (1961), Migrants at Ocean Weather-ships, *Bird Migration*, 1, pp. 245-49.
3. Matthews, G.V.T. (1955), *Bird Navigation*, Cambridge University Press.

C. K. ANANTHASUBRAMANIAN  
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Coimbatore-641 038

#### II

Sir, The phenomenon of birds flying towards the source of light and allowing themselves to be captured without any attempt of self-defence or escape is very interesting. In his article *The Jatinga bird mystery* (S.R., September 1979), Sengupta has listed some essential environmental factors for this peculiar behaviour of birds. Probably this is due to the sudden change in the magnetic field of the place. This may sound strange; but sometimes truth is stranger than fiction. It is known that animals and birds are more sensitive to electromagnetic waves and supersonic sounds, etc., than human beings. This is explained in a book *Sunspots and Their Effects*. It is also noteworthy that the bursting of the Koyna Dam in Maharashtra years ago was attributed partly to the magnetic properties of the storage water. Probably the geological conditions between Jatinga Railway Station and the Village Health Centre are such that the conditions listed by Sengupta produce a steep change in the magnetic properties of the underground sto-

rage water in the region thereby affecting the magnetic field in the particular area for a temporary duration. This probably disturbs the psychological condition of the birds and they react mechanically and just fly towards the source of light as the firefly flies towards a source of light.

K. A. VIEWANATHAN  
Reader in Mathematics  
IDSG Govt. College  
Chikmagalur  
(Karnataka)

#### III

Sir, I read with interest *The Jatinga bird mystery* (S.R., September 1979). In this connection, I am reminded of *Pakshithirth*, a temple situated on a hilltop near Madras. At this place, two birds come daily at about 11 a.m. Every day thousands of pilgrims visit this place before 11 a.m. to observe the arrival of birds. The *pujari* (priest) of the temple reaches the peak with *prashad* and drinking water. Near about 11 a.m., the birds appear there. First they perform *parikrama* of the temple. The *pujari* chants some mantras facing the east side. Then a *thali* is beaten by a spoon informing the pilgrims of the arrival of the birds. On the sound of the *thali*, birds come to the *pujari*, eat some *prashad*, drink water and again fly away. Remaining *prashad* is distributed among all pilgrims.

It is said that the two birds have been coming to this place daily since 7th century. In 1447 and 1487, some Dutch and European tourists visited this place and wrote about the birds. The birds are similar to owls.

In this age of science, arrival of birds, eating *prashad*, drinking water and flying back, daily at the same place remains a mystery.

O. P. JAIN  
Botany Department  
P.M.B. Gujarati Science College  
Indore (M.P.) 462001

#### IV

Sir, I read with great interest the article by Sudhin Sengupta, *The Jatinga bird mystery* (*S.R.*, September 1979). I thank the author because I had heard before that so many birds are attracted at nights in a village of Assam in certain months of the year. But I had no clear idea about it. Being a Zoology Honours student, I was waiting for such an article on this mystery. This article has invited the attention of the avian biologists to the unique phenomenon, not occurring anywhere else in the world. All the four environmental factors, i.e., dark night, strong directional wind from south to north of the village (30 kmph-50 kmph), dense cloud and good rainfall which were absolutely essential for the influx of birds towards the source of artificial light help to solve the mystery. The reason why in this particular region such a striking phenomenon occurs is not clear. I hope *S.R.* will provide more information to readers on these queries.

VIJAY KUMAR DASS HARI  
C. M. Science College  
Darbhanga (Bihar)

#### V

Sir, *The Jatinga bird mystery* (*S.R.*, Sept. 1979) by Sengupta should attract naturalists to uncover the mystery of the Jatinga bird. It is surprising that since 1905 the people of Jatinga village have been eating the flesh of the birds but no ornithologist has tried to study this bird mystery, the unique and most peculiar. Why don't ornithologist like Salim Ali take interest and solve the Jatinga bird mystery?

ASHOK KUMAR SAHU  
Kendriya Vidyalyaya  
Duliajan (Assam) 786602

#### The story of $\pi$

Sir, The article *The story of  $\pi$*  by K. R. Parthasarathy (*S.R.*, Sep-

## SCIENCE REPORTER

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tember, 1979) has really been a pleasant reading. But it leaves us in the dark as before in regard to the irrationality of  $\pi$ . He has, however, hinted at the end of his article that Lindemann succeeded in establishing the result by use of the famous Euler's formula  $e^{\pi i} = -1$ . The readers will appreciate if he furnishes a formal proof of the same in an understandable way.

ASIM MOOKHOPADHAYA  
Dept. of Mathematics  
Charuchandra College  
Calcutta 700029

#### II

Sir, I feel K. R. Parthasarathy in his exhaustive article *The story of  $\pi$*  (*S.R.*, Sept. 1979) should have explicitly and prominently referred to the fairly accurate results obtained for  $\pi$  by the two early Indian mathematicians, Aryabhata and Bhaskaracharya, after whom our two satellites have been named.

An interesting point about  $\pi$  is that its value has been calculated upto 10,000 decimal places, with the help of the computer. This demonstrates the capacity of modern methods of computation, but is otherwise of little practical significance. Because

if  $\pi$  is calculated to 40 decimal places it would give the circumference of the entire visible universe with an error imperceptible even with an electron microscope.

S. K. GURTU  
Defence Science Laboratory  
Metcalfe House  
Delhi-110054

#### Jupiter—the largest planet

Sir, The information provided by D. C. Goswami (*Planets of other stars*, *S.R.*, September 1979) that the planet of Barnard's star possesses a mass 1.6 times that of Jupiter, and the planet of 61 Cygni A has a mass 10 times that of Jupiter was interesting.

George Gamow in *The Birth and Death of the Sun* has inferred that all solid bodies, more massive than Jupiter, are destined to a complete internal collapse and that their ultimate radii must be expected to become smaller than that of Jupiter. Thus Jupiter represents geometrically the largest piece of cooled matter that can, in principle, exist in the universe.

S. K. GURTU

#### For Her

Sir, I have been reading *S.R.* for quite some time now. I request you to find some other title for the column *For Her*. As it stands, it gives the impression that women are capable only of reading the *For Her* column in *S.R.*; and that the only aspects of science which can interest a woman are those connected with cosmetics or housekeeping!

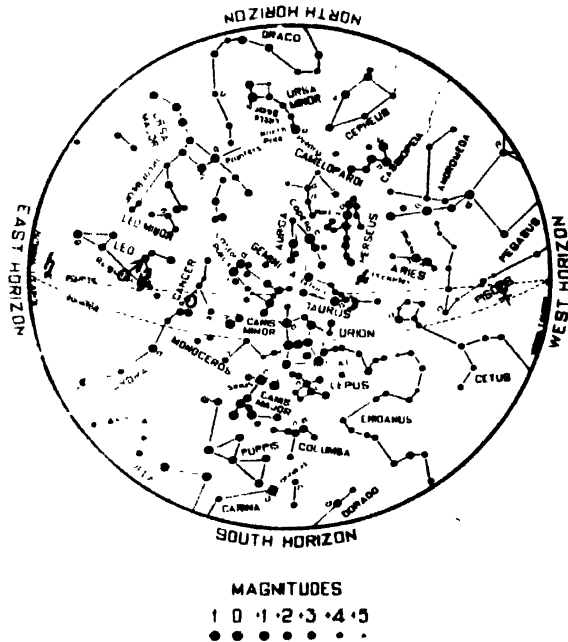
I am surprised that such an enlightened body of men, as I am sure the *S.R.* staff is, should help in perpetuating such irrational, unscientific and unsound attitudes towards women.

ANS

HASPATI  
211003

# Planets and their positions

February 1980



## PLANETS

VENUS ♀  
JUPITER ♃  
MARS ♂  
SATURN ♄

## MOON

○ FULL MOON 1ST  
☾ FIRST QUARTER 23RD

## The moon

**F**ULL moon occurs on 1st at 7.51 a.m. and the new moon on 16th at 2.21 p.m. I.S.T. The moon passes about half a degree south of Jupiter on 3rd, three degrees south of Mars in the very early hours of 4th, two and a half degrees south of Mercury on 17th and about three and a half degrees

south of Venus on 19th. The lunar crescent becomes first visible after the new moon day in the evening of 17th.

The moon is at apogee or farthest from the earth on 5th and at perigee or nearest to it on 17th.

An occultation of the planet Saturn by the moon will occur in the very early hours of 5th. The phenomenon will be visible in India.

At Delhi the planet remains covered by the moon from 0.12 a.m. to 1.26 a.m. and at Calcutta from 0.32 to 1.59 a.m. I.S.T.

## The planets

**Mercury (Budha)** reappears as an evening star, sets about an hour after sunset during the month. It is at the greatest eastern elongation of about  $18^\circ$  from the sun on 19th. It becomes retrograde on 26th. Towards the end of the month it is too near the sun to be visible. It moves from Capricorn (*Makara*) to Aquarius (*Kumbha*). Its visual magnitude varies from  $-1.1$  to  $-1.6$ .

**Venus (Sukra)** an evening star, sets about three hours after sunset during the month. It moves from Aquarius (*Kumbha*) to Pisces (*Mina*). Its visual magnitude is about  $-3.6$ .

**Mars (Mangala)** rises about two hours after sunset during the first half of the month and sets at about sunrise during the second half. It is at opposition with the sun on 25th. It is in Leo (*Simha*). Its visual magnitude varies from  $-0.6$  to  $-1.0$ .

**Jupiter (Brihaspati)** rises at about sunset and sets at about sunrise. It is at opposition with the sun on 24th. It is in Leo (*Simha*). Its visual magnitude is about  $-2.0$ .

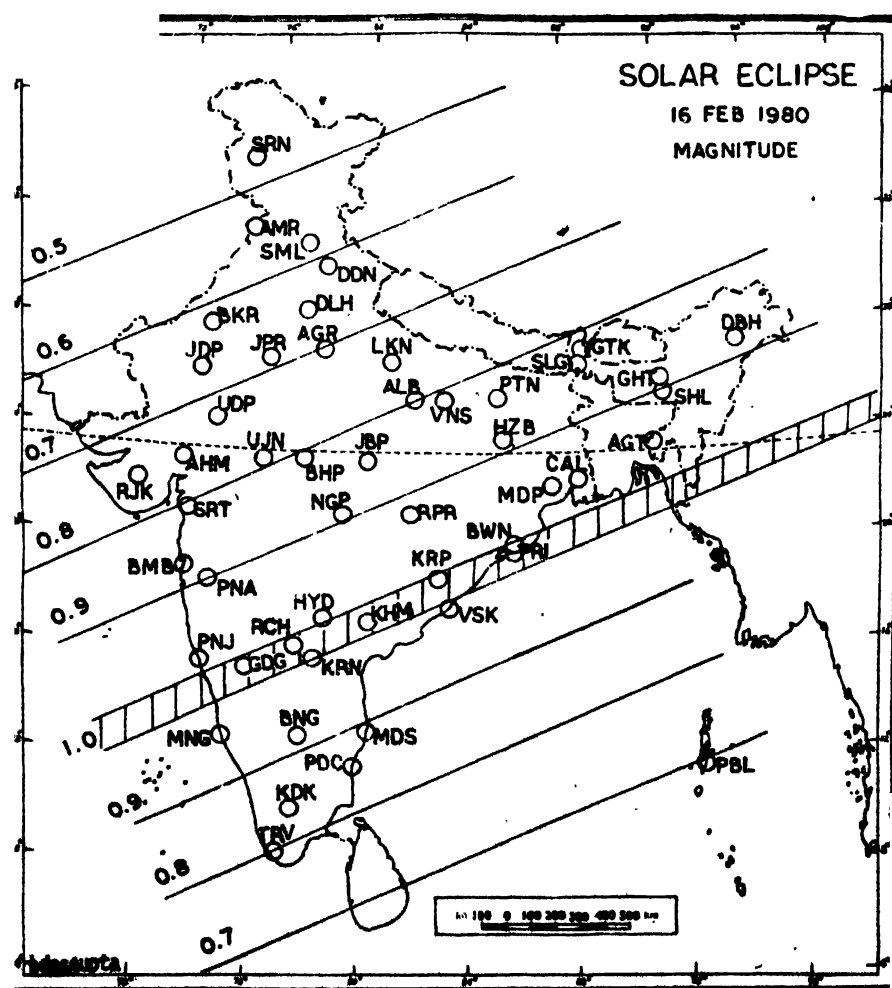
**Saturn (Sani)** visible in the morning sky, rises about two and a half hours after sunset during the first half of the month and about one and half hours after it during the second half. It is in Virgo (*Kanya*). Its visual magnitude is about  $+0.9$ .

## TOTAL SOLAR ECLIPSE (Feb. 16, 1980)

There will be a total eclipse of the sun on 16th February 1980 (see also *S.R.*, August 1979). This solar eclipse will be one of the most important astronomical events of this century for India, as the path of

Table 1. Local circumstances relating to some important places in India

Place	Eclipse Begins (IST)	Totality Begins (IST)	Time of Greatest Phase (IST)	Totality Ends (IST)	Eclipse Ends (IST)	Magnitude
	h m s		h m s	h m s	h m s	
Bangalore	14 23 26	—	15 43 34	—	16 53 34	0.92
Berhampur*	14 40 17	15 52 55	15 54 05	15 55 15	16 59 10	1.03
Bhubaneswar*	14 42 15	15 54 47	15 55 10	15 55 33	16 59 35	1.03
Bombay	14 18 38	—	15 40 06	—	16 51 45	0.87
Calcutta	14 46 47	—	15 57 27	—	17 00 12	0.96
Delhi	14 36 09	—	15 47 23	—	16 51 16	0.66
Gadag*	14 21 03	15 41 00	15 42 23	15 43 46	16 53 31	1.04
Gauhati	14 51 42	—	15 59 22	—	16 59 56	0.88
Hubli*	14 19 58	15 40 24	15 41 40	15 42 56	16 53 08	1.04
Hyderabad	14 28 14	—	15 46 55	—	16 55 54	0.99



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line. Based upon Survey of India outline map printed in 1979

Fig. 1

totality passes over the Indian peninsula. The last total solar eclipse which could be clearly seen over Central India was on January 22, 1898.

Considering the earth as a whole, the eclipse begins at 11.45 a.m. I.S.T. and ends at 17.01 p.m. I.S.T. and will be visible over the part of the globe extending from long. 30°W to long. 120°E and from latitude 60°N to latitude 35°S, i.e., practically the whole of Africa, Saudi Arabia, Iraq, Iran, Afghanistan, Pakistan, India, Nepal, Bangladesh, Sri Lanka, Burma, Malaya, Thailand, Philippines, Indonesia, China, Mongolia and U.S.S.R.

The totality on Indian peninsula begins at the West Coast at 15.39 I.S.T. near Ankola (in Karnataka). The moon's shadow then moves in a north-easterly direction after sweeping over Andhra Pradesh and Orissa and finally leaves the east coast near Puri at 15.56 I.S.T. and again touches a small stretch in Mizoram. Table 1 gives local circumstances relating to some important places in India. Fig. 1 shows lines of constant magnitude at maximum of the eclipse. The magnitude for any place in India can be roughly found from

Table 1. (Contd.)

Place	Eclipse Begins (IST)	Totality Begins (IST)	Time of Greatest Phase (IST)	Totality Ends (IST)	Eclipse Ends (IST)	Magnitude
Karwar*	14 17 20	15 38 36	15 39 56	15 41 16	16 52 10	1.04
Khammam*	14 31 16	15 47 32	15 48 48	15 50 03	16 56 48	1.04
Koraput*	14 36 41	15 51 03	15 52 01	15 53 00	16 58 19	1.04
Kurnool*	14 26 21	15 45 24	15 45 44	15 46 05	16 55 14	1.04
Madras	14 29 06	—	15 46 55	—	16 54 59	0.89
Nagpur	14 32 06	—	15 48 45	—	16 56 20	0.89
Puri*	14 42 03	15 53 56	15 55 04	15 56 12	16 59 33	1.03
Raichur*	14 25 11	15 43 40	15 45 01	15 46 22	16 54 55	1.04
Srinagar	14 39 56	—	15 43 45	—	16 42 05	0.47

Magnitude is the fraction of the sun's diameter obscured by the moon at the time of greatest phase.

\*Totality of the eclipse is visible at these places.

it. Fig. 2 illustrates how the eclipsed sun will be seen in the sky from certain places in India at the greatest phase.

The darkening of the sky during totality will permit only the bright stars and the planets (Mercury, magnitude  $-0.6$  and Venus, magnitude  $-3.4$ ) to be visible to naked eye.

#### How to watch it

Watching a partially eclipsed sun may be as hazardous to the naked eyes as the uneclipsed one. It is, therefore, essential to understand the hazard and take precautions as given below:—

The intensity of sunlight for direct safe viewing should be reduced by at least 100,000 times and ultraviolet and infra-red part of the solar radiation should be effectively cut off. The most effective and easily accessible filtering aid is two thicknesses of black-and-white photographic film completely exposed and developed. Another safe device is the dark arc-welder's glass.

Smoked glass, polarising material, colour film or sunglasses are not safe

(Continued on page 34)

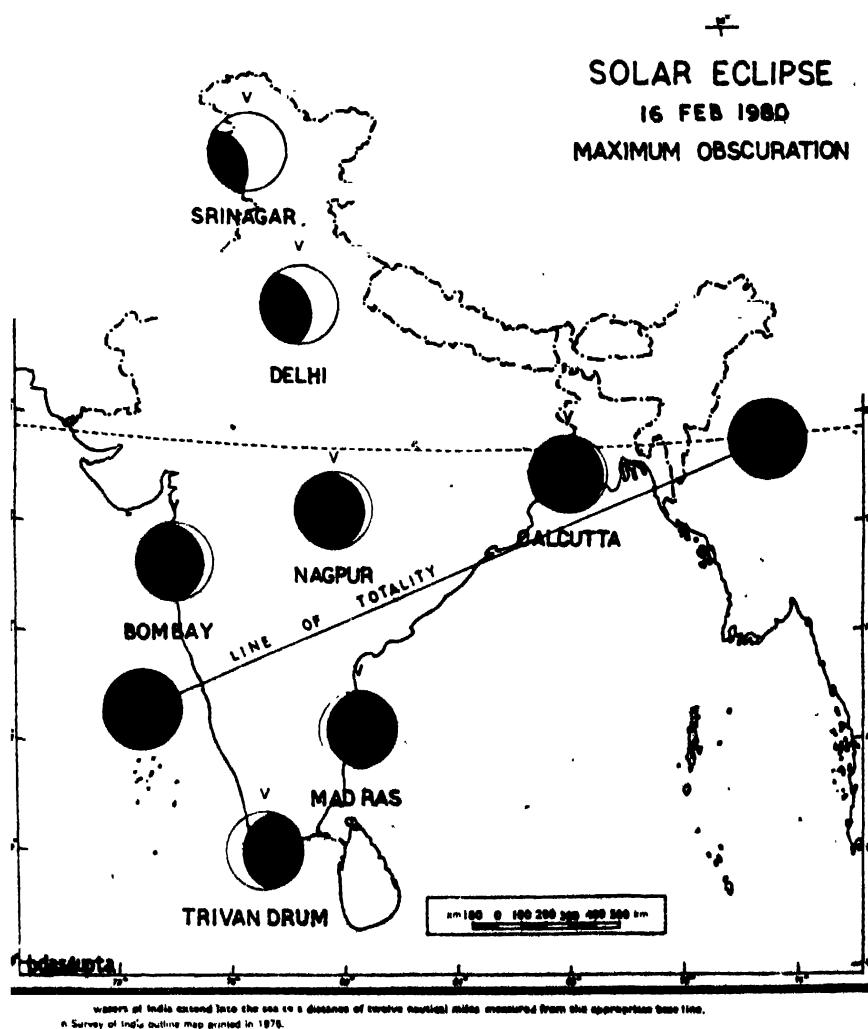
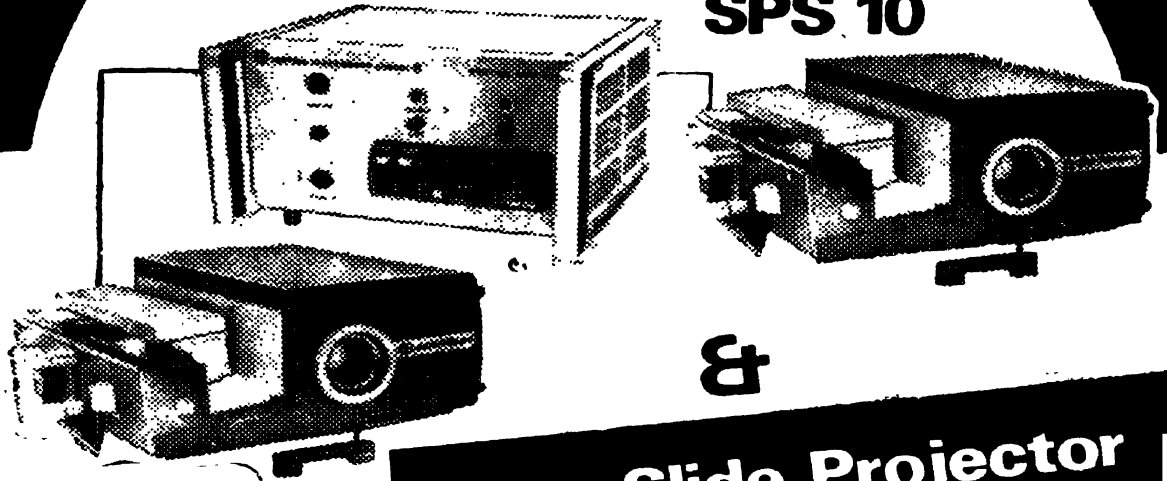


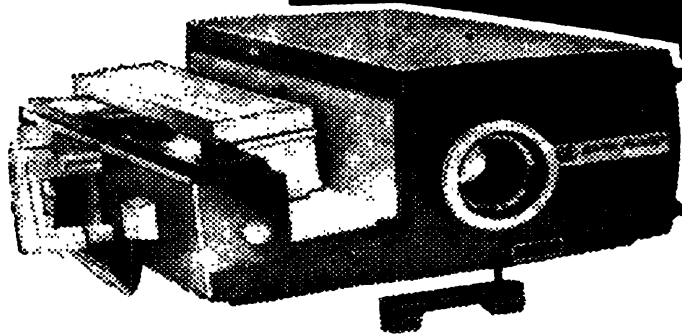
Fig. 2

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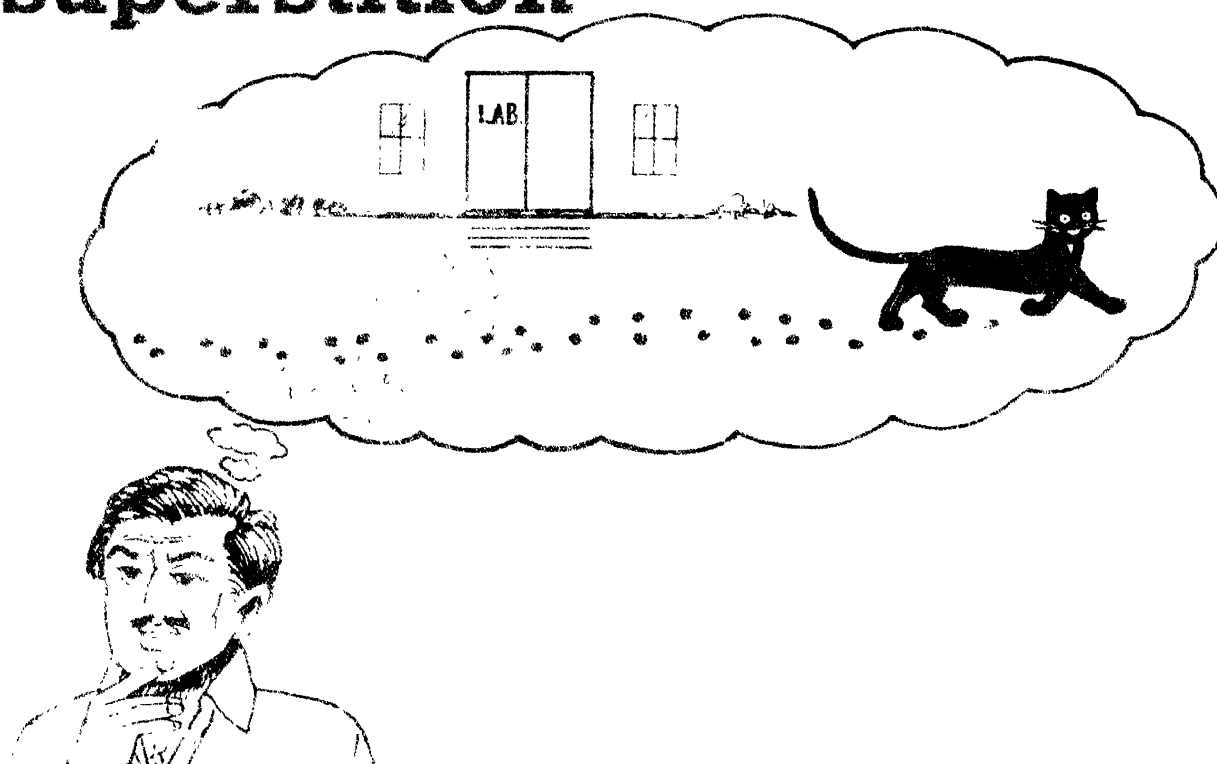
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# Science against superstition



Not all superstitions beliefs are without a scientific basis but most of them cannot stand scientific scrutiny

SHANTOO GURNANI      MADHURI SHETH

**E**ACH one of us knows that superstitions play a prominent part in our daily life. We are not necessarily aware of the kind of superstitions we follow or the role they play. Superstitions in our life go by various names such as rituals, beliefs, customs and personal values. The etymological definition of superstition includes credulity in supernatural agencies, irrational fear of the unknown, and also any belief not based on sufficient evidence. Yet another view, that of a physicist Nobel

Laureate P. Kush is that "Superstition of today is knowledge of former times, (but) it is *unexamined* knowledge". We see that superstition has a very wide definition. In this article, therefore, we will discuss only some examples of superstitions which have been investigated scientifically and some of these which need to be investigated.

Superstitions are not confined to any particular religion or culture. They are spread over all human socie-

ties. The term superstition as it stands is ambiguous and has subjective connotations. For simplification, superstitions are qualified as religious, cultural, and personal. The practice of superstitions not only varies with the type of religion and culture, but also with each individual. While religious and cultural superstitions are shared by a community and hence are accessible to investigation, personal superstitions are not easily accessible for study and understanding.

Dr. Gurnani is with Biochemistry and Food Technology Division, Bhabha Atomic Research Centre, Bombay. Dr. Sheth is with National Institute of Training Industrial Engineers, Bombay

## Sneezing

Let us cite here some of the superstitions prevalent in most parts of the world. One of them concerns sneezing. Now sneezing can occur to anybody, anytime, at any place in the world. To the superstitious, however, there is something prophetic and ominous about it. Some even believe that internal convulsions may disturb and drive out the soul. Hence the common custom of blessing the sneezer to ensure the return of the soul to its proper abode. Others consider it a good or ill omen depending on when and where the sneeze occurs; it even matters very much on which day it occurs. Here is an old rhyme cited by Lore Cowan indicating various meanings that sneeze foretells.

Sneeze on Monday, you sneeze  
for danger  
Sneeze on Tuesday, you kiss a  
stranger  
Sneeze on Wednesday, you sneeze  
for a letter  
Sneeze on Thursday, for some-  
thing better  
Sneeze on Friday you sneeze for  
sorrow  
Sneeze on Saturday, your sweet-  
heart tomorrow  
Sneeze on Sunday, your safety  
sake  
The devil will have you whole of  
the week.

Medically sneezing is the body's defence reaction to remove a foreign material which has somehow got into nasal passage. Yet we continue to adhere to the old superstition; we lack a questioning attitude.

## Throbbing of the eye

What a great part does right and left play in our belief! Take, for instance, the twitching of an eye. Which is auspicious for a woman, left or right? Of course; it is left. Throbbing

of the left eye brought hope in Seeta's lonely hours during her captivity in the Ashoka Vatika. She wondered and, Lo! and behold, she met Hanuman on that day and received Rama's message. But what does physiology say about the twitching of an eye? It occurs because of the excitation of a nerve which leads to an aberrant contraction and relaxation of the eye muscles. It can be logically contended that Seeta's eye must have twitched because of the tension she was undergoing during her captivity. Since the side from which the tension is relieved is a random choice, a correlation between events and the twitching eye is irrelevant. This is one of the examples to show how our beliefs have come to be enmeshed in folklore and history.

Even some great men in literature were afflicted with such an irrational habit of mind. It is said that Voltaire used to be in bad temper whenever he heard a raven croak on his left.

## Scientific investigations of prenatal influences

Medical and psychoanalytical investigators have come to the conclusion that not all the phenomena considered superstitious beliefs from time to time are amenable to scientific investigation. However, some of those beliefs which have been examined tend to confirm that there is substantial truth at least in some of them.

For example, there has long been a belief in most societies that a pregnant woman is in a vulnerable state particularly to the influences of spirits, and to changes in the position of the stars and planets. Therefore, she must follow certain taboos. It is widely held that she should expose herself only to pleasant experiences, see photographs of beautiful children and should not get easily worked up, etc. During the eclipse, a pregnant woman is advised to lie

down quietly in a dark room and not to expose herself to the environmental influences till the eclipse is over.

Advances made in medical field also maintain that the prenatal experiences definitely affect the foetus in various ways. Medical evidences of the last two decades strongly support the view that, not only physical illness of the mother, but also her experiences of psychological stress, can adversely affect the foetus. It may result in malformations or defects in the nervous system, producing intellectual or behavioral disturbances. It is also an established fact that the lunar cycles have adverse effect on mentally affected people. Most recent developments in biomedical sciences define health as a state of harmony between the magnetic fields of different groups of cells in the body. It would, therefore, seem that the recommendation to pregnant women to keep cheerful in pleasant settings is a sound advice. Our ancient story of Krishna and his pregnant sister Subhadra (Arjuna's wife) is interesting in this context. The unborn Abhimanyu, yet in the womb, is said to have heard his uncle explaining to Subhadra about the method of entering the *Chakra Vryuh*. To the rational mind, this would appear as a figment of imagination. But, a reasonable reflection would show that this probably is an exaggerated, symbolical and parable style of expressing the same prenatal influences. Naturally, visual symbolism to convey abstract thoughts to common folks was the most important vehicle of communication in those days when there was no written language. Rites and rituals probably originated in pre-language days as observed by J. Bronowsky: "When there is no language, when you have nothing that can be called chemical formula then you must have a precise ceremonial which fixes the sequence of operations so that they are exact and memorable".



## Smallpox

Similarly, Edward Jenner the discoverer of smallpox vaccine, made his important discovery by pursuing a superstition commonly prevalent among farmers. While an apprentice in his teens, he had heard about a local belief in Gloucestershire that people infected with cowpox from cattle were immune to smallpox. His contemporary physicians refused to pay attention to such tales, but the same probably inspired Jenner's experiments which led to the scientific confirmation of the belief.

## Other superstitions

Superstitions about numbers, colours, metals, and precious and semi-precious stones are common. Most of these are personal superstitions depending upon fancy of an individual. Number 13 phobia is a familiar example. Colours, numbers, stones and zodiac signs are supposed to somehow influence human destiny.

## Amulet

An amulet is an object which is either carried or worn or placed in the house as a protection against evil or evil designs of other people. The most common method followed in our country is to make a pendant and tie it around the neck or on the left or right arm. The pendant (*Taviz*) usually contains some written verse, e.g., *Japsahib*, *Koran*, or *Pantisakhri*, Mantram or a picture of a god or a living guru. The other common practice is to wear a copper bangle either in the arm or on the foot to cure or keep away illness (a practice not only prevalent in India but also in U.K.). A ring compounded of seven metals is worn to keep away spirits and ghosts.

Here is an interestingly written amulet-abracadabra, a word very popular with magicians. The follow-

ing form is written on paper and hung about the neck to counteract illness. It is believed that as the lines diminish, so will the illness (Cowan, L., 1968).

ABRACADABRA  
ABRACADABR  
ABRACADAB  
ABRACADA  
ABRACAD  
ABRACA  
ABRAC  
ABRA  
ABP  
AB  
A

The warding off of the illness by such magical methods is prevalent in India, but is probably predominant in some areas. In Kerala and Lakshadweep, these practices are still popular.

## Origin

Anthropologists and psychoanalysts have paid particular attention to study and understand the origin of superstitions. The old schools of these disciplines rely heavily on Freudian interpretation. Modern behaviorists mainly depend on surveys and studies of behavioral patterns in animals. But how far such data can explain human behaviour is not clear.

The simple explanation which appears self-evident is that man suffers from the fear of the unknown. This fear creates tension and stress. He tries to know the future and particularly the harmful events so that he can take preventive measures.

The alternative explanation proposed by G. Jahoda, Professor of Psychology, University of Strathclyde, Glasgow, is related to the basic human characteristics of perception and thinking. According to him, man has the tendency to structure the environment into cognizable

patterns and to find meaning in the most diverse groups of events in order to derive satisfaction from such an achievement. Conversely, he feels threatened and disturbed when an environment or an event fails to make sense.

## Superstition—a forerunner to science

Magic may be forerunner of most scientific activity. Birth of many sciences begins with simple but crude hypotheses which arouse imaginative thoughts. This is evident in pseudo-sciences such as alchemy and astrology from which chemistry, astronomy and mathematics have emerged. This view is also held by Karl Popper who feels that nearly all scientific theories originate from myths and that myths may contain important anticipations of scientific theories. In support, among other examples he traces the origin of the theory of evolution to Empedocles' idea of trial and error. Perhaps, the Indian idea of man having to undergo 84 transformations (जुनी) also has connotations for the evolution theory.

## Scientists' responsibility

Once superstitions get fixed, it is not only difficult to dislodge them, but also they seem to multiply. Science is Latin word for knowledge. To quote P. Kush again, "an essential quality of science is its dynamism, the continuing search for new knowledge of nature, for new insights, for new formulations of ever inclusiveness for precision and elegance." With the evolution of the society, the social patterns also keep changing perceptibly and imperceptibly depending upon the impact of new knowledge through various media, arts, science and technology. Taboos and rituals which do not serve any function often die out but new ones spring up.

### Colour value spectrum

Good							Bad			
White	Blue	Violet	Lilac	Rose	Green	Red	Orange	Purple	Yellow	Black
Purity	Affection	Intelligence	Freshness	Sweet disposition	Hope	Health Strength	Luxury	Pride	Falseness	Sadness

Here, scientists can help in two ways; (a) by examining deep rooted superstitions through scientific investigations, and (b) by disseminating information about scientific discoveries related to existing superstitions. Since scientific method is based on causation, examination of the superstitious beliefs with unbiased mind should help bring out the facts underlying a variety of those phenomena which are presently dubbed superstitions. The knowledge thus acquired would provide information regarding their correctability or improbability. And it goes without saying that with new knowledge old superstitions would soon be dispelled. However, scientists must remember that common man will

understand causation only in his own language. Therefore, they must demystify science for conveying the facts to layman. The famous psychiatrist Thomas Harris has explained that it is necessary "to develop a 'Public' language decontaminated of technical jargon and suited to the discussion of universal problems for a particular cultural society." This means that scientists must convey scientific knowledge to people in their own cultural patterns.

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### FOR HER (Continued from page 65)

In some groups of animals, a dense layer of cells called the 'decidua' (Fig. 1) is formed around the embryo. It was believed to provide immunological protection. In case of ectopic pregnancy, that is, where the fetus develops outside the womb (in the intestine or the fallopian tube) there is no decidua but still pregnancy continues upto a certain extent. Therefore, it is not the decidua which affords protection to the fetus.

#### The trophoblast

In early stages of pregnancy, the fetal tissue specialised for contact with the maternal tissue is the trophoblast now called trophoectoderm. It is probably due to

the presence of this layer that the fetus owes its privileged position as an allograft. The trophoblastic or trophoectodermal cells are surrounded by a fibrinoid material--sialic acid rich mucopolysaccharide. It has been found that cells of the trophoectoderm grafted to anatomically unnatural sites or injected in a separate individual fails to provoke an immune response. Transplantation antigens are present on cells of trophoectoderm but their refractoriness may be due to the presence of a cell coating that may repel lymphocytes. Another interesting find is that the higher the genetic incompatibility between the mother and the fetus the greater is the invasion of the trophoblast within the uterus.

These facts indicate that the trophoblast or the trophoectoderm provides a considerable degree of protection to the fetus. This protection, may be by several modes; (a) The mucopolysaccharide barrier might provide protection against cytotoxic lymphocytes, (b) Cells of trophoectoderm may be resistant to lymphocytic attack, (c) A certain substance may be secreted and elaborated by the structure which may be immunosuppressive in nature. However, there are some other possibilities which remain to be investigated.

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OUR understanding of the organisation of protein coding genes in higher organisms has recently begun undergoing a revolution. Analyses of eukaryotic as well as prokaryotic genes now suggest in general that coding sequence on DNA—the regions that are ultimately translated into amino acid sequence—are not continuous but are interrupted by what is now called as ‘Silent DNA’. Even in the genes which do not code for protein (e.g., tRNA genes of yeast, rRNA genes in *Drosophila* and viral messages from adenovirus, Rous sarcoma virus and murine leukaemia virus) the primary RNA transcript contains internal regions that are excised during maturation, the final tRNA or mRNA being a spliced product.

The development of sophisticated recombinant DNA techniques has led to the isolation of a number of animal genes—ovalbumin, globin, immunoglobulin, histone to name a few. These genes were studied as defined by the mRNA or protein sequence to characterize the start and end of each gene in the hope of discovering common control features. To make things simple, it is known that primary sequence of the protein is determined by mRNA which in turn is synthesized on one of the strands of genomic DNA, probably first as a precursor of high molecular weight (hnRNA). Several animal mRNAs on being sequenced have shown that the coding sequence, which starts with an initiator triplet and is read to the 3' terminator triplet, is preceded by a capped, non-translated region. Restriction en-

## About DNA that is SILENT

**The discovery of silent DNA is the latest and most dramatic demonstration of the striking differences that sets apart prokaryotes from eukaryotes**

donuclease mapping of total genomic DNA followed by hybridisation of the resulting DNA fragments with a probe specific for structural gene sequences are the two complementary approaches that have recently led to the discovery that eukaryotic genes and their mature RNA products need not be strictly colinear as had been previously assumed and that the initial or primary transcript

of a gene is longer than the mRNA largely because all the intervening sequences are transcribed and subsequently chopped out (spliced). Restriction mapping method is more quantitative in that fragment sizes and position can be correlated with known distances in the structural sequence. However, in the absence of favourably placed restriction sites, some intervening sequences may be

missed. Electron microscopy of the RNA-DNA hybrid technique permits more direct analysis of intervening sequences and detects additional intervening sequences.

### Experimental evidence

In rabbit  $\beta$ -globin mRNA the sequence of bases starts at one end with the triplet specifying the N-terminal amino acid of the protein and moves without interruption to the other end where the protein terminates. But in the gene the sequence of bases coding for  $\beta$ -globin is not continuous. In particular one fragment of cloned complementary DNA (obtained by reverse transcription of mRNA) which is 333 base pairs long hybridises to a restriction fragment of genomic DNA that is more than twice as big. Evidently the restriction fragment contains an additional insert of some 700 base pairs length (which is as big as the structural gene for  $\beta$ -globin itself) in the middle of the gene which does not appear in the final mRNA (Jeffreys, A. J. and Flavell, R. A., *Cell*, **12**, 1097, 1977).

Recently, Leder, P. *et al.* of U.S.A. (*CSH Symposium* 1977), upon reverse phase chromatography (which separates according to base composition and secondary structure) after having purified the mouse  $\beta$ -globin gene many hundred times, got two fragments approximately 15,000 and 7,000 base pairs long respectively. Each of these though much more purified over the original DNA, still contained one globin containing sequence. The mixture was then recombined with suitably disabled vector. Recombinants containing the mouse  $\beta$ -globin gene were selected. The cloned mouse DNA which was ten times the size of the coding sequence showed upon hybridisation with mouse globin mRNA, an extra loop in the middle of DNA. Restriction enzyme analysis confirm-



Fig. 1

ed the existence of a 450 base pair (bp) long intervening sequence.

Using specific restriction enzymes R. Breathnach of the Laboratory of Genetics and J.L. Mandel of the Institute of Chemical Biology, Strasbourg, France (*Nature*, **270**, 314, 1977) have demonstrated that there is an interruption in the chicken chromosomal DNA sequences coding for ovalbumin mRNA between the  $Hin$   $f_2$  and  $Mae$  III sites and again between  $Mae$  III and  $Hin$   $f_4$  of the double stranded complementary DNA (cDNA). These interrupted segments were not represented in mature mRNA.

F. Rougeon of the University of Genie Genet, Paris, France (1977) working with reverse transcriptase used a 300-400 nucleotide long cDNA preparation to synthesize the double stranded Rabbit  $\beta$ -globin DNA, and after amplification ended up with a 100-150 b.p. long integrated globin DNA which was only about one fifth of the length mRNA. Thus he indicated that non-coding silent DNA occurs together with the protein coding one. The mouse Immunoglobulin (Ig) sequence when inserted into plasmid vector is only about 700 bp long whereas Ig mRNA is 950 bp long indicating that about 200 bases of light chain mRNA sequence must be missing from the cloned sequence (Seidman, J. E. and Leder, P., 1978).

Analysis of the gene coding for mouse (Tilgham, S.M. *et al.*, *Proc. Natl. Acad. Sci.*, USA, **74**, 4406, 1977 and **75**, 725, 1978), mouse Ig' light chain (Brack, C. and Tonegawa, S. (*Proc. Natl. Acad. Sci.*, USA, **74**, 5652, 1977), yeast tRNA (Goodman, H. M. *et al.*, *Proc. Natl. Acad. Sci.*, USA, **74**, 5453, 1977), *Drosophila* ribosomal genes (Glover,

D.M. *et al.*, *Cell*, **5**, 149, 1975), haemoglobin mRNA, many virus mRNAs and cellular mRNAs (Darnell, J.E. Jr., *Science*, **202**, 1257, 1978) have all resulted in the hitherto unexpected finding that these DNAs contain additional sequences (DNA regions) which are not used in encoding and are, therefore, not represented in the final gene product. A. Dugaiczky *et al.* of Baylor College of Medicine, Houston, Texas, USA (*Nature*, **274**, 328, 1978) have recently shown that by cloning the  $ECORI$  fragments of the natural ovalbumin genes followed by hybridisation, restriction enzyme analysis and electron microscopy of the hybrid formed between the closed DNA and ovalbumin RNA the structure gene sequences coding for ovalbumin were found to be separated into eight sequentially oriented pieces by seven intervening sequences of various lengths (Fig. 1). This chick ovalbumin gene according to Robertson *et al.* of Cambridge (1979) is a particularly extreme example of an interrupted gene. Intervening sequences of about 1200 bp length have also been reported between the V-C junctions (V=amino terminus; C=carboxy terminus) in a Ig protein chain (Brack and Tonegawa, 1977), ovomucoid gene (J.F. Catterell *et al.* *Nature*, **278**, 323, 1979), human foetal globin gene (P.F.R. Little *et al.* of St. Mary's Hospital, London and University of Amsterdam — *Nature*, **278**, 227, 1979) thus establishing them in eukaryotes too. Illustration on page 14 shows what gene inserts look like the eukaryotic DNA.

Though whether a split gene yields a correct mRNA remains yet to be established (for there is no accurate enzyme known to cut transcribed inserts out), scientists have given possible

models to account for that. Bob Williamson of St. Mary's Hospital and Medical School, London (1977) maintains that untranscribed regions along with RNA polymerase transcribe in the ordered fashion the ovalbumin gene to yield directly the mRNA. Catterell, J.F. *et al.* of Texas and Cambridge suggest (1978) that potentially an RNA polymerase transcribes only exons leaving the introns thus giving the correct mature RNA. The primary nuclear RNA transcripts that are larger than mRNA may be cleaved but selected pieces may 'splice' back together to yield the mature mRNA (Darnell, 1978). According to another hypothesis RNA polymerase synthesizes a copy of the entire gene copying both introns and exons regions. This pre-mRNA could be cut and exons joined in the correct order leaving behind the introns. Spliced genes of adenovirus (Chow, L.J. *et al.*, 1977)  $\beta$ -globin (Tilgham *et al.*, 1977) ovalbumin (Williamson, 1978, 1977), yeast tRNA (Goodman, *et al.*, 1977) support the latter mechanism. Yet another model (Tonegawa, S. *et al.*, *Proc. Natl. Acad. Sci.*, **75**, 1485, 1978) proposes that the two adjacent exons however distant in an Ig  $\lambda$  chain pre-mRNA could be brought into close proximity by the formation of a hydrogen-bonded duplex regions between the two ends of the respective function regions. The splicing enzymes then by a specific and precise mechanism could bring the distantly located exon sequences into close contact and join them up correctly in the pre-mRNA. This ligation of RNA molecules has been referred to as RNA. RNA, splicing by Darnell, J.E. Jr. of Rockefeller University, New York (1978). According to this mechanism since the base pairing occurs between adjacent junctions larger hairpin loops may be generated out of the introns. This model gives an immediate structure of higher cells which are now shown to have high molecular weight

heterogenous RNA (hn RNA). Out of this hn RNA, the transcription product the smaller messengers for expressed polynucleotide sequence are spliced.

In spite of all these suggestions it seems, a bit too early to speculate the role the split gene organisation might have had in the regulation of gene expression at the transcriptional and/or post-transcriptional level.

### Conclusions and genetic implications

The discovery of silent DNA has made an important breakthrough in the field of molecular genetics. According to Walter Gilbert of Harvard University, USA (*Nature*, **271**, 501, 1978) the concept of cistron—the genetic unit of function—must now be replaced by that of a transcription unit containing regions which will be lost from the mature messenger. In other words, a gene now corresponds not to one polypeptide chain but to one transcription unit (i.e., many polypeptide chains). The regions which would express into a mature mRNA are called 'exons' interrupted by 'introns' which would remain unexpressed (silent) and finally be lost from the mature mRNA. He conceives gene to be a mosaic holding exons in a matrix of silent DNA. The DNA in introns is expected to be many times more than what may be present in exons. This model may take well into account the extra DNA (over that needed to code for genetic products) that may be present in higher cells. The details of intron-exon structures became clear subsequently and many authors regard intron-exon model an established one (see Garpin *et al.*, *Cell*, **14**, 629, 1979, Gannon *et al.*, *Nature*, **278**, 428, 1978).

That eukaryotic structural genes are interrupted by sequences of silent non-informative DNA is now referred to as the 'gene-in-pieces' struc-

ture. C. C. F. Blake of the University of Oxford has recently (*Nature*, **273**, 267, 1978) come forward with an attractive explanation that 'gene-in-pieces' in fact implies protein-in-pieces and the exonic regions of DNA correspond to integrally folded protein units—domains or super-secondary structures. According to this model a new enzyme could be formed by the combination of two or more domains (exons) (folded into a stable globular form) which branch out the amino acid side chains and thus contribute towards the formation of active site. This might shortly in future be tested by sequencing the DNA known to code for domain enzymes.

'Silent DNA' model may eventually turn out to bring important events to successful completion in eukaryotic cells development. Since the gene is spread over a larger region of DNA, recombination for want of DNA molecules to get together, may be hampered in higher cells. Recombination within introns may generate hot spots for eukaryotic genes. These hot spots may thus be brought into a transcription unit to make special differentiation products. These special gene products might in turn on new splicing patterns thus determining new differentiation pathways.

There are different explanations as to why such massive nucleotide sequences should be retained and not deleted from the proteins especially when they are not used as a part of mRNA. Some authors maintain that the capacity to streamline a genome by discarding DNA sequences not demanded by environmental stress is rather a late development in evolution, whereas broken gene organisation has been in existence in eukaryotic genes for a long time. W.F. Doolittle (1978) proposes that genes-in-pieces and splicing represent an early state of cell evolution. This split structure was present in the genomes

of the common ancestors of both prokaryotes and eukaryotes. According to him the bacteria while becoming streamlined shed the flexibility offered by splicing while eukaryotes successfully specialized by retaining this very early arrangement of genetic material. This splicing of RNAs according to a recent view might generate novel proteins more rapidly than could the single mutations which are of rare occurrence. The evolution proceeds by making use of new as well as old gene products and this is what the introns provide. Studies on rabbit and human globin mRNAs have yielded information that a larger section of the 3' non-coding regions is significantly conserved in evolution. This conservation of the sequence might possess defined sequence specific functions.

There have been two major thoughts regarding the origin of divided genes. According to first the genes that arose first had continuous sequences. But as eukaryotic cells evolved from a prokaryotic cell precursor the urge for sophistication in control was satisfied by the development of RNA. RNA splicing ability with subsequent insertion into transcriptional gene areas. The second view holds that eukaryotic cells are composed of DNA that was never contiguous and therefore has not become divided. According to this view the separated eukaryotic DNA segments were recruited long ago within the same transcriptional unit and become established as a functioning gene because RNA, RNA ligation allowed the use of all the protein coding information within the primary RNA transcript.

This RNA, RNA splicing pattern development from primary transcript of broken gene could have facilitated evolution either very early when a functional genome made its start or during cellular evolution when most of the complex cellular capacities arose. Thus according to Darnell (1978) the complex of biochemical reactions that results in mRNA formation is the chief evolutionary basis that draws the line between eukaryotes and prokaryotes. Since many of the post-transcriptional events in mRNA formation, viz., capping, poly (A) addition or splicing—have not been reported in bacteria. Darnell regards that sequential evolution from prokaryotes to eukaryotes is unlikely and eukaryotes have evolved independently of prokaryotes rather than by insertions into prokaryotes.

W.F. Doolittle (1978) also disbelieves that tightly organised prokaryotic genome is primitive and argues that eukaryotic genes-in-pieces organisation is in fact primitive original form. Since progressive evolution of higher forms is seen as a corollary of progressive increase in genomic complexity (Britten, R. J. and Davidson, E.H., *Q Rev. Biol.*, **46**, 111, 1971 and others), the origin of this type of organisation could be a bit difficult to explain. Gene inserts may be now thought to play a part in progressive evolution but their introduction into unique essential gene is most often lethal (Kleckner, 1977). It is now suggested (Doolittle, 1978) that DNA replication, transcription as well as translation have been unfaithful in the last common ancestor of prokaryote and eukaryotes. Unfaithful systems evolve

rapidly and in such cells a genes-in-pieces organisation with RNA splicing have current (evolutionary) as well as additional role to ensure that exons (which may often be incorrectly replicated and transcribed) were at least occasionally assembled to template functional proteins. As replications, transcription and translation became more faithful, such systems became less necessary and replication and transcription of this non-informational silent DNA became more and more irrelevant. These, therefore, were eliminated gradually. The bacteria were first to pay the price. The higher forms retained it accidentally.

Whatever be the extent to which we have understood the broken gene organisation, it has already created sensation in the field of molecular biology by bringing startling facts and possibilities in light. It may soon, it is hoped, solve many nagging problems that still exist in genetics.

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# **CAPACITOR MICROPHONES —**

**pressure-operated  
devices for quality  
performance**



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S. S. HEMMADI**

**The use of capacitor microphones is well established for recording, entertainment, broadcasting and acoustic measurements, etc., as they possess a high sensitivity and good frequency response in the audio range, and produce no background noise like other types of microphones**

**T**HE capacitor microphone was developed over fifty years ago as the first studio and laboratory audio frequency pick-up device capable of precise calibration and having a smooth well-defined response. Prior to this, microphones

had been mainly carbon granule or moving coil devices with irregular and often unstable response characteristics. The capacitor microphone was a considerable advance on previous studio microphones in respect of smoothness of response, linearity,

etc., which made it suitable for use in broadcasting and recording studios where the highest sound quality is desired.

Capacitor microphone is a pressure operated device. When a sound source emits sound, it does so by

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producing very rapid vibrations in the air which are superimposed on the steady atmospheric pressure. If the pressure variation can be isolated from the atmospheric pressure, a small cyclical force is available to derive a light diaphragm system. A microphone which is designed to isolate the atmospheric pressure and utilise the remaining cyclical pressure for electrical reproduction of sound waves impinging on it is known as pressure operated microphone.

### Working of capacitor microphone

The capacitor microphone depends for its action on the variation of capacitance between a tightly stretched metallic diaphragm situated in close proximity to a rigid metal backplate. The backplate is insulated from the remainder of the microphone and a polarizing voltage is applied between it and the metallic diaphragm. Sound pressure acting on the diaphragm causes it to vibrate about its mean position and so varies the capacitance between the backplate and the diaphragm. In the presence of acoustic pressure the voltage across the capacitor is given by

$$V = Q/C$$

where  $Q$  is the charge stored in the capacitor of capacity  $C$ , and  $V$  the voltage applied for polarising via the resistor  $R$  (Fig. 2).

Sound pressure changes the spacing between the diaphragm and the backplate by an amount, say  $\Delta s$ . The spacing at any instant is  $s \pm \Delta s$  and the capacitance at that instance is  $C \pm \Delta C$ .

Then,

$$C \pm \Delta C \propto \frac{1}{s \pm \Delta s}$$

where,  $a$  is a constant. If the value

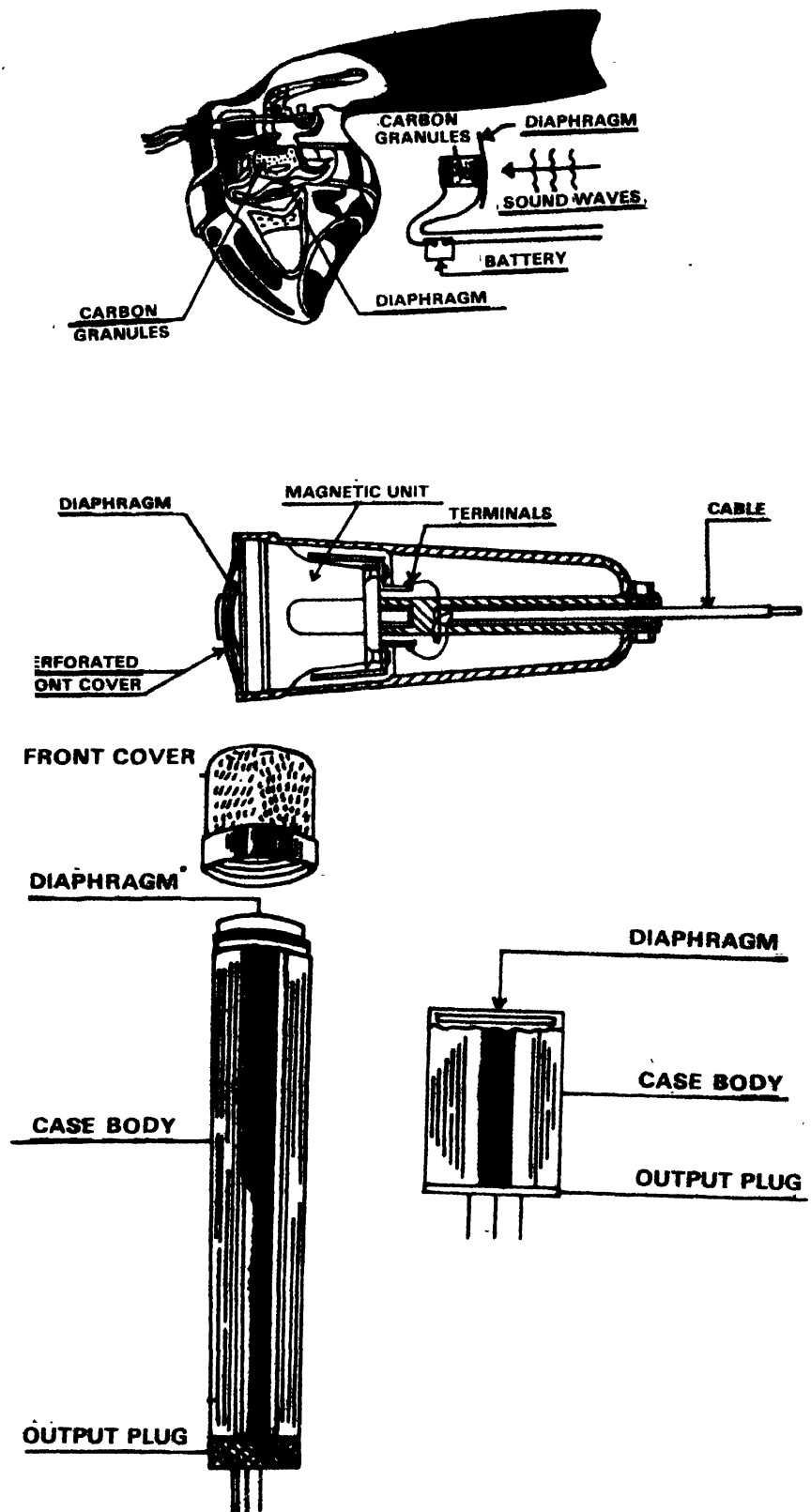


Fig. 1. Various types of microphones: (Top) carbon microphone (used in telephone mouthpiece), (Middle) Dynamic microphone, (Bottom left) capacitor microphone (Bottom right) electret microphone



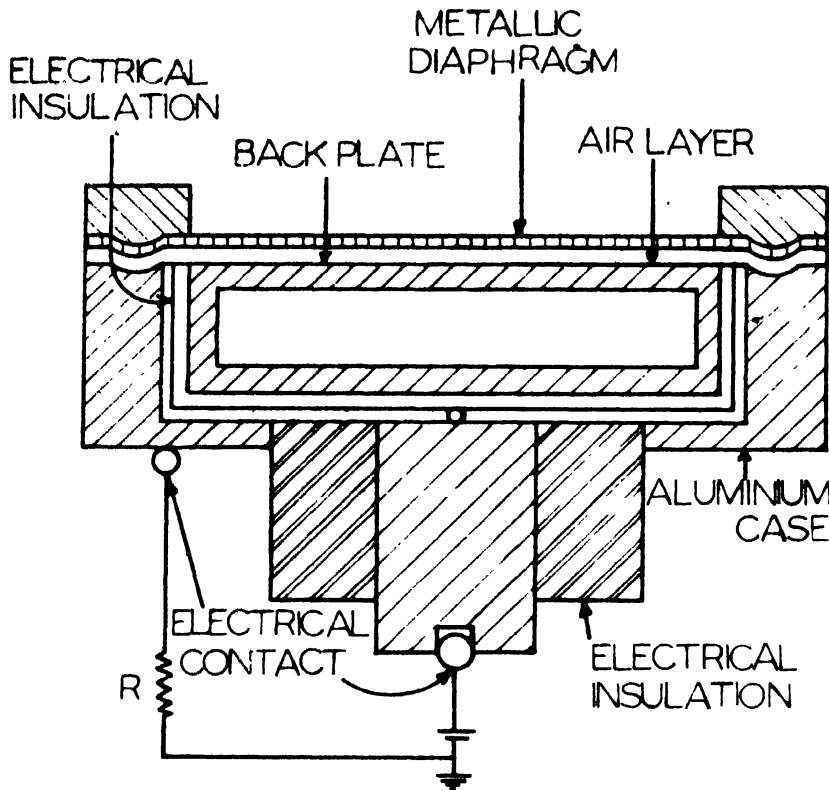


Fig. 2. Cross-sectional view of a capacitor microphone

of the resistance is large, the charge  $Q$  is virtually constant.

Then,

$$C \pm \Delta C = \frac{Q}{V \pm \Delta V}$$

As  $a$  and  $Q$  are constants,  $\Delta V$  is proportional to  $\Delta s$ . That is, the variations in voltage across the capacitor, which constitute the output of the microphone, are proportional to the displacement of the diaphragm. The conventional air gap capacitor microphone shown in Fig. 2 has many desirable features such as flat frequency response, a good impulse response, and low distortion. However, two shortcomings have limited their use: (1) The small capacitance, about 10 picofarads per  $\text{cm}^2$ , requires that they should be coupled directly to a vacuum tube amplifier; and (2) They require a dc bias usually between 50 volts -- 200 volts.

The rather low capacitance of conventional capacitor microphones is primarily due to the wide separation between the electrodes and the use of air as the dielectric.

A capacitor microphone with high capacitance (of the order of 50 picofarads per  $\text{cm}^2$ ) can be made by using a thin metallised dielectric film as diaphragm and placing it very close to the backplate. As the capacity of such a solid dielectric capacitor microphone is higher than that of conventional air gap capacitor microphone, amplifiers with a correspondingly lower input impedance can be used. However, the solid dielectric microphone still requires a dc bias.

#### Electret microphone

The elimination of the dc bias has been achieved by several methods. For instance, microphones using thick wax electret (an electret is a

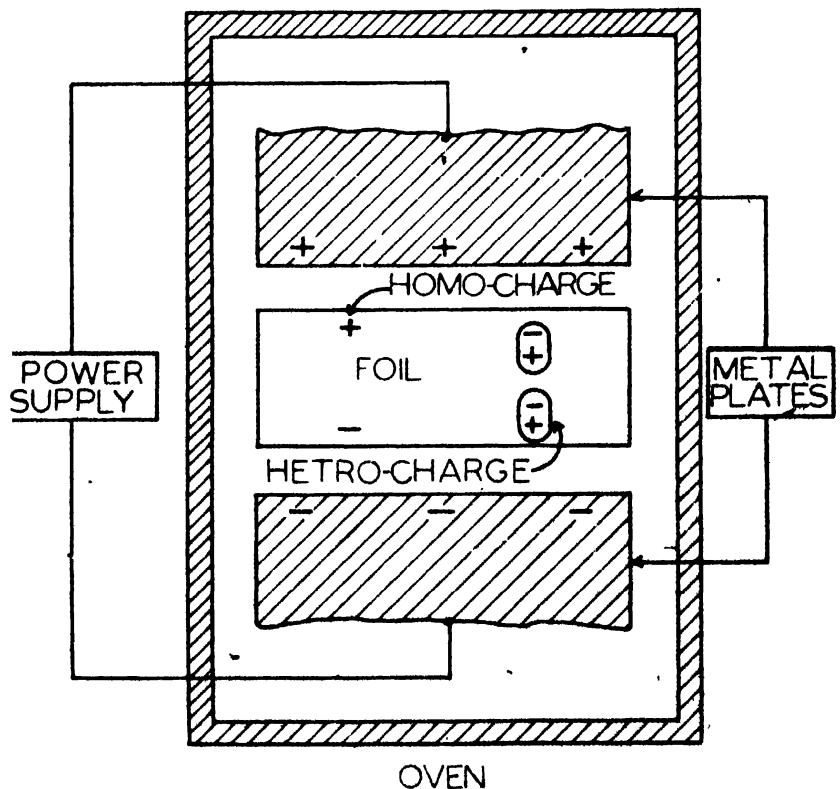


Fig. 3. Polarising process for dielectric foils

dielectric material in which permanent polarization can be induced) have been built. But the disadvantage of such systems is the very large separation between the electrodes, which leads to a very small capacitance. Also, the life of wax electret is short.

Another possibility to eliminate the dc bias is the use of prepolarised thin polymer foils. Microphones with prepolarized foil exhibit the following characteristics:

1. The polarization of the foil electrets eliminates the need of an external dc bias which is necessary in conventional air gap capacitor microphones;

2. They exhibit constant sensitivity over a period of years; and

3. They have relatively high capacitance because of the closer spacings of the electrodes and high dielectric permittivity of the foil.

The electret microphone is similar in construction to conventional air gap capacitor microphones. Only the metallic diaphragm of air gap microphone is replaced by prepolarized polymer foil. The foil consists of a dielectric material such as polyester or fluorocarbon which is metallised on one side. These foils, when suitably charged, retain the charge for years in all weather conditions. The capacitance of a typical electret microphone with 6.25 micrometer thick foil and having a diameter of 3.8 cm is about 600 picofarads, which is about 10 times higher than that of air gap capacitor microphones.

The usual method of making an electret is by thermoelectret process (Fig. 3). The polymer foil is heated to its softening temperature and exposed to a voltage greater than 20 kilovolts per cm for a time long enough to partially orient the dipoles between the two parallel metal plates. The foil is then allowed to cool slowly in the presence of the field. This ensures that the dipole orientation is maintained during cooling. The polarising field is then removed

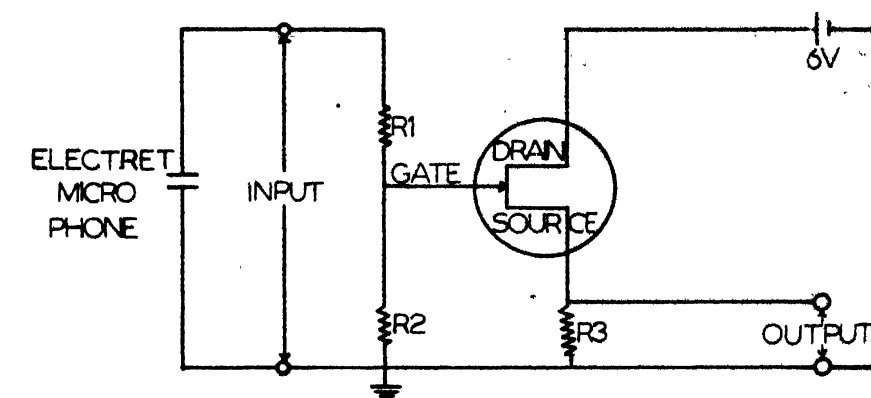


Fig. 4. Impedance matching of capacitor microphone to a transistorised amplifier

and the dipoles remain frozen in their oriented position. The polarization of the foil consists of hetero and homo charges. (Fig. 3) The hetero charge consists of dipoles that have been aligned by the field at high temperature. The external field created by the hetero charge has the opposite polarity to that of polarizing field. The homo charge consists of a positive space charge on one side and a negative space charge on the other side of the electret. The homo charges exist because electrons are relocated in the foil, or electrons migrate between the foil and the metal plates during the polarizing process. The polarity of the field produced by the homo charge is same as that of the polarizing field.

In the deposited charge method, the electret is formed by bombarding the material with charged ions either from a corona discharge in air or from an electron beam. When dielectric films are exposed to corona discharge, charges get trapped at or very near to the surface of the film, which in turn provide the permanent polarization of the material. In the other process, the foils are exposed to electron beam in vacuum. This method is capable of considerable control, as the choice of beam voltage allows one to select the penetration depth while beam current and exposure time control the injected charge density into the dielectric material.

#### Low-noise impedance transforming input amplifiers

Capacitor microphones are generally unsuitable for coupling directly to normal transistor amplifiers using bipolar junction devices. The transistor amplifiers have relatively low impedance circuits which seriously alter the response of the capacitor microphones. Although electret microphones have a capacitance which is about one order of magnitude greater than air gap capacitor microphones (about 40 pf at 30 hertz), this is also well above the impedance range of normal transistors, while for amplification purposes the input impedance of the amplifier should be more than 100 megohms if a flat frequency response is to be maintained.

In the past, electrometer-type vacuum tubes have been used for the input stages of amplifiers. But transistor amplifiers are preferable because of small size, less power consumption, robustness and longer life. The advent of field effect transistor (FET) has solved the problem of amplifier coupling with capacitor microphone. The use of FET in the preamplifier stage lowers the high impedance of the capacitor microphone which facilitates the use of transistor amplifiers (Fig. 4).

The FET may be regarded as a voltage operated device which behaves more like a vacuum tube than a nor-

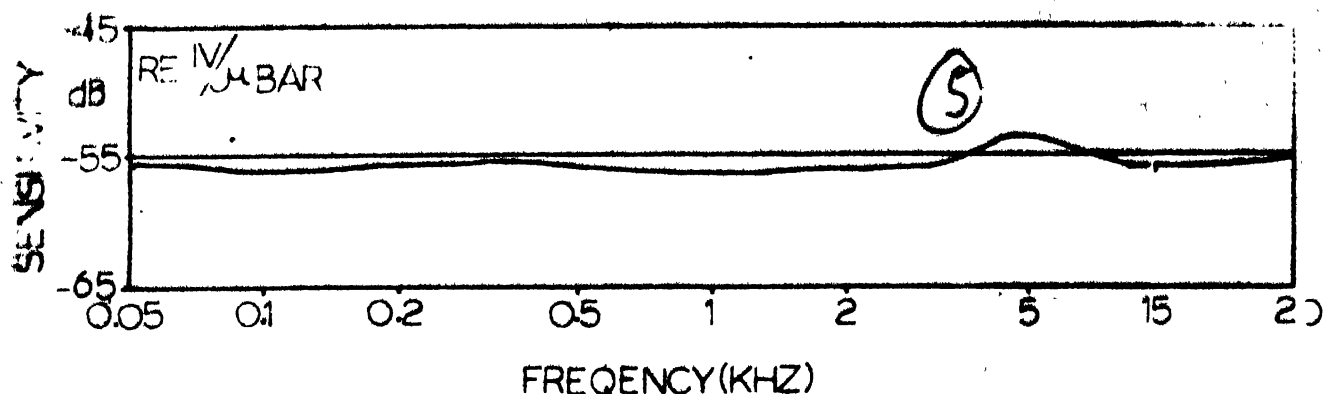


Fig. 5. Frequency response of an electret microphone

mal transistor. The biasing voltage requirements, size and shape are like that of a normal transistor, but its characteristics are like a vacuum tube. Conduction occurs through a semiconductor channel between the source and drain in presence of supply potential. The current is controlled by the width of depletion regions determined by the controlling voltage applied to the gate electrode (Depletion regions are areas in a semiconductor where the carriers have been substantially removed owing to the potentials and fields established across the pn junctions.)

In many ways the junction FET has ideal characteristics as an input amplifying device for high impedance transducers. Their input impedance is high, the noise level can be made very low and quite high amplifications can be obtained.

#### Performance

The frequency response of an electret microphone having a capacitance at about 500 picofarads is shown in Fig. 5. The response is with-

in 1.5 dB from 50 cycles per second to 15000 cycles per second. Their sensitivities generally lie between -50 and -60 dB V for a sound pressure level of 1 micro bar. The lower limit of the dynamic range of electret microphones is determined by noise levels. The self noise of these microphones has been found considerably below that of low noise preamplifiers. As shown in Fig. 5, electret microphones have a more or less flat frequency response in the audio frequency range, low distortion, and an excellent impulse response.

In order to determine the suitability of polymer films for use as a diaphragm in the electret microphone extensive studies have been made in India on various imported as well as indigenously available polymer films such as polyvinyl chloride (PVC), polyvinyl acetate (PVAc), polyvinyl fluoride (PVF), polyvinylidene fluoride (PVF<sub>2</sub>), mylar and teflon with reference to charge injection, charge decay under various ambient and polarizing conditions. Various charging devices were tried to find suitable charging method for a particular polymer film. These studies have revealed various parameters such as nature

and thickness of polymer films, electret life time, etc.

Considerable work has also been done on the mechanical design of these microphones. Suitable microphone matching impedance and pre-amplifier arrangements have been developed using field effect transistors. The prototypes of electret microphones were fabricated and tested which were found satisfactory. These microphones are ideal for tape recorders and would also be useful in hearing aids, earphones, studio applications and sound measuring instruments, etc.

#### Further reading

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3. Gayford, M. L. (1970), *Electroacoustics*, Newnes-Butterworths, London.



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HEM SHANKER RAY

**Many changes in science, technology and society follow exponential laws of one kind or another. They have profound implications in long-term predictions of technological and social change**

nential increase pertains to money deposited in the savings bank account in a bank. If the bank account has a constant interest, compounded annually, then the total savings may increase slowly at first but, consequently, it begins to rise very rapidly. If  $Y_0$  is the initial amount and  $r$  is the annual interest rate, then the amount in the account after  $t$  years will be :

$$Y_t = Y_0 \cdot \exp. K_t \quad (1)$$

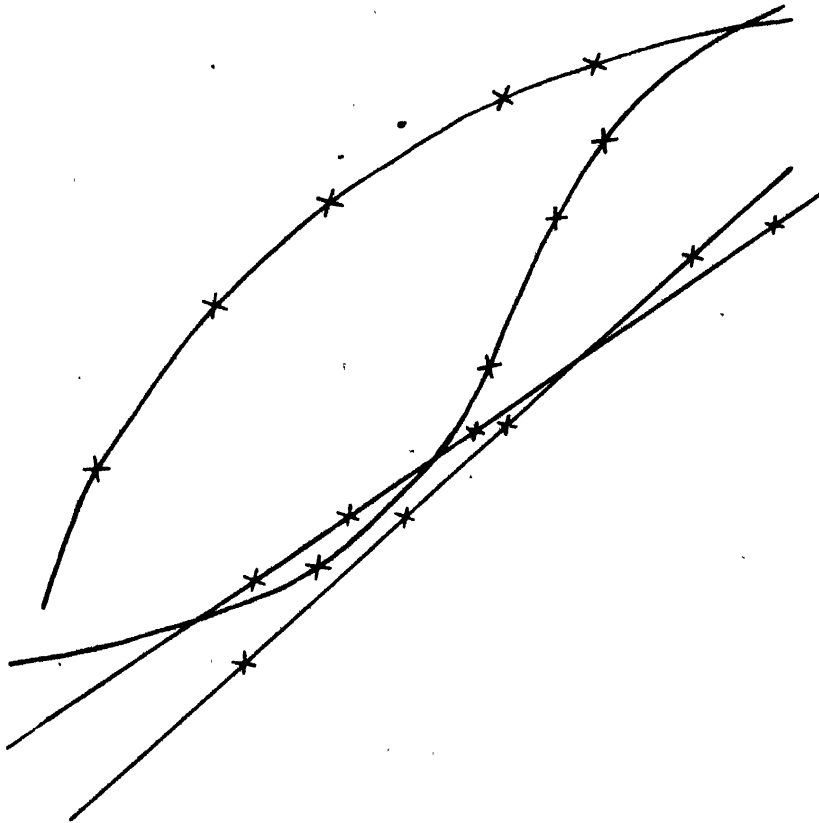
where  $K$  is a constant which equals  $\ln(1+r)$ .

We say that the variation of the total amount in the bank with time is exponential. The derivation of exponential equations is carried out subsequently.

It is not usually realised how widely this law and similar laws are valid in science, technology and society in general. This article examines this with examples from different areas and also discusses some implications in relation to long term predictions of technological and social change.

#### **Some simple types of exponential variation**

We shall now see how the exponential increase or decrease of a vari-



## **EXPONENTIAL VARIATION WITH TIME**

### **a natural law of change**

**W**E have all heard the story of the clever man who asked a king for a grain of rice one day, two grains for the second day, four grains for the third, eight for the fourth and so on for a month or two. The not-so-intelligent king agreed and brought upon himself ruin by not realising the mathematical significance of the proposition. Although it was a matter of a few grains initially, the king had to deal with enormous quantities very soon because of the

increase of the daily ration at an increasing rate.

There are several types of mathematical functions which describe similar variations of a variable  $y$  with respect to another variable  $x$ . The exponential function is one among them. In exponential variation, in general,  $y$  may either decrease or increase with increase in the value of  $x$ , the rate of change gradually changing.

A well-known example of expo-

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able is an automatic consequence of a constant rate of change (e.g., constant birth rate expressed as births per 100 persons per year, constant rate of invention expressed as percent growth in the number per year, etc.). Consider a variable  $y$  and its variation with time  $t$ . Some simple types of exponential variations are shown in Fig. 1.

**Type 1a : Exponential growth at increasing rate :** Type 1a which shows increase of  $y$  at an increasing rate is the most obvious kind of exponential variation. This describes the growth of the savings bank account and general population in many countries. The variation follows the simple law :

$$\frac{dy}{dt} = K \cdot y \text{ or } \frac{(dy/y)}{dt} = K \quad \dots (2)$$

where  $K$ , again, is a constant.

This gives,

$$\ln y = Kt \quad \dots (3)$$

If we consider the limits  $y = y_0$  at  $t = t_0 = 0$

$y = y_t$  at  $t = t$

$$\text{then } \ln (Y_t/Y_0) = Kt \quad \dots (4)$$

$$Y_t = Y_0 \exp. Kt. \quad \dots (1)$$

Eqs. (1) to (4) are based on the basic premise that the rate of change of  $y$  (with time) is proportional to the value of  $y$  at the given time and that the rate of change of  $y$  per unit value of  $y$  is constant. So, if we say that every 100 people add to the population 3 persons per year then  $K$  has a value .03/yr.  $K$  has the same value if a bank account grows cumulatively with a rate of interest of three per cent. With a fixed value of  $K$ ,  $y$  goes on increasing at an increasing rate as shown in Fig. 1 (a) because  $dy/dt$  increases as  $y$  increases.

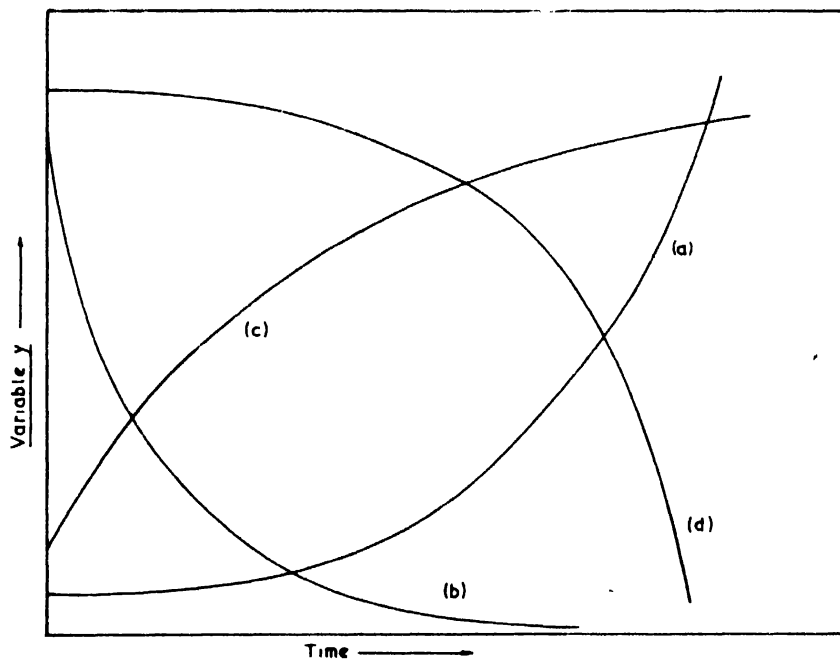


Fig. 1. Some types of exponential variations

Many natural phenomena, technological changes scientific developments, etc., follow this trend and, therefore, the exponential law is made use of for long-term projections using a linear plot according to Eq. (4). Such forecasts, often called heuristic forecasts, are discussed in greater detail subsequently.

**Type 1(b) : Exponential decay at gradually decreasing rate :** If the variable  $y$  decreases with time we can write a 'decay' equation :

$$\frac{dy}{dt} = -Ky \quad \dots (5)$$

$$\text{which gives } Y_t = Y_0 \exp. (-Kt) \quad \dots (6)$$

The well-known radioactive decay follows this law. Particles are transformed because of radioactivity, the rate being proportional to the number of particles present. The rate gradually goes down because of the decrease in the number of particles and a complete decay would take infinite time. To compare the decay rate of different radioactive

elements, therefore, one makes use of the (finite) time for 50% transformation—the so-called 'half-life' period.

**Type 1(c) : Gradually diminishing rate of increase :** This is complementary to Type (b) and may be seen as the difference of curve (b) from a fixed quantity. So is, if (b) represents the number of particles decaying, (c) represents the number of particles which have already decayed. Note that the sum of the two, the total number of particles originally present is a constant.

Consider another example. Suppose a furnace is kept at a fixed temperature  $T_f$  and a piece of metal is suddenly put inside. The piece is originally at the room temperature. It is obvious that initially the piece would begin to get heated up fast but gradually the rate of heating would diminish as the temperature of the metal approaches the final equilibrium temperature—the temperature of the furnace itself.

As a first approximation, let us assume that, at any instant, the rate

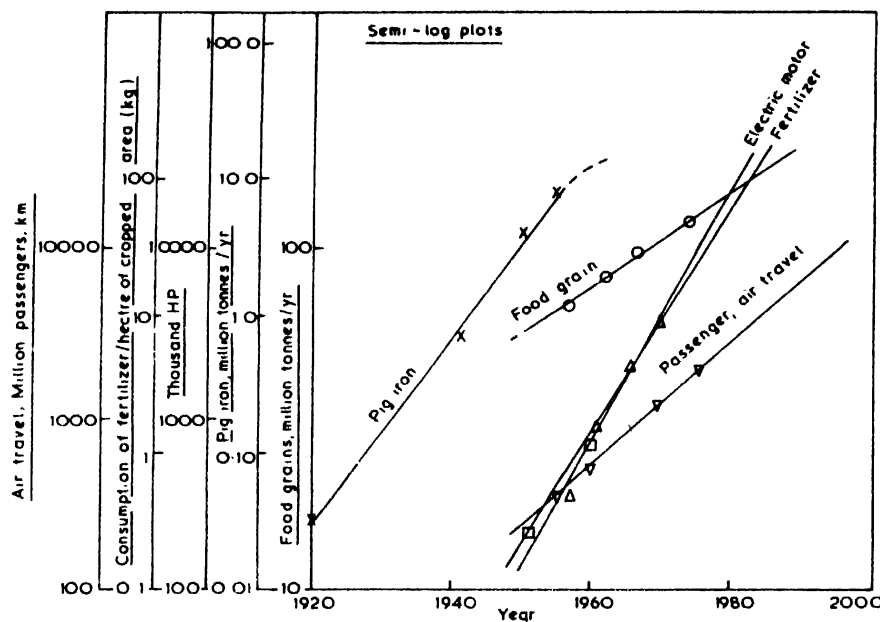


Fig. 2. Heuristic forecasts

of heating is proportional to the temperature difference between the furnace and the metal piece.

In other words,

$$\frac{dT}{dt} = -K \cdot (T_r - T) \quad \dots (7)$$

where  $T$  is the temperature at time  $t$ .

If  $T_0$  is the initial temperature, then integrating Eq. (7) within the limits  $t=0$  to  $t=t$  one gets

$$\ln \left\{ \frac{T_r - T_t}{T_r - T_0} \right\} = -Kt$$

$$\text{i.e. } (T_r - T) = (T_r - T_0) \exp. (-Kt) \quad \dots (8)$$

If we write  $y$  in the place of  $T$ , then Eq. (8) gives eq. for the curve (c).

This type of exponential variation is found in many situations where a variable  $y$  increases towards a final value.

**Type 1(d): Exponential decrease at gradually increasing rate:** The radioactive decay example pertains to a decreasing rate situation. We

can think of an opposite trend where the decline of a variable  $y$  is small initially but the rate gradually increases with time. This is represented by curve (d) in Fig. 1. Curve (d) may be seen as complementary to curve (a). So (d) can be derived by subtracting (a) from a fixed quantity. If the total amount of money in a bank was fixed, then (a) shows the growth of a particular account and (b) represents the drop in the share of savings belonging to others. If a particular section of a community accumulated wealth according to curve (a), then curve (d) would show the decline of the wealth owned by the rest of the community if the total wealth of the community was fixed. Again, if the total population is fixed and curve (a) indicates the increase in the number of literates, then curve (d) would indicate the drop in the number of illiterates.

It is of interest to note that when there are complementary variables, as discussed in the preceding paragraph, then the rapid growth of one must lead to simultaneous rapid decline of the other.

The equation of the curve (d) would be based on the basic premise,

$$\frac{dy}{dt} = -K(A - y) \quad \dots (9)$$

where  $A$  is a constant.

### A fundamental question

One can ask as to why it was necessary to assume a constant 'rate coefficient'  $K$  in the exponential models. Firstly, it is the simplest and most straightforward assumption. Secondly, it offers an idealised trend against which actual trends can be assessed. The exponential equations can be plotted as straight lines in semilog plots. If data in any particular case exhibits deviations, it is easy to discern whether the data has a systematic bias, whether the trend is faster or slower than an exponential or whether the deviations merely tend to oscillate around a mean. Sometimes the deviations are directly due to short time disturbances, e.g., in the case of production of consumer goods due to war, economic recession, etc., and when the causes for the temporary deviations are removed the variable jumps back to the original trend. Sometimes, however, the deviations represent more than a temporary affair and there may be important reasons why the simple exponential variation is no longer adequate.

For example, consider the growth of the number of books in a library. Suppose that the librarian initially adds to the stock new books at the rate of 5 per cent of the total holdings. If there is such a fixed rate, then the total number of books increase exponentially. Many famous libraries have actually followed this trend. Such exponential growth implies that an increasing number of new books are bought every year. So the annual grant for new books must increase every year (even disregarding inflation!) If at some point financial curbs freeze the annual grant to purchase a fixed number of books

every year, then the semilog plot would indicate a drop away from a straight line.

### More complicated models

It should be obvious that in many real cases a simple exponential variation cannot describe the changes adequately. Consider a model of scientific progress. If we assume that the rate of increase in the accumulation of information  $I$  is proportional to the total number of information which already exists, to a probability that a scientist entering a unit of information will react and create a new unit of information and to the number of scientists  $N$  in the field, then the rate of increase in  $I$ ,

$$\frac{dI}{dt} = K \cdot N \cdot I \quad (10)$$

where  $K$  is a constant.

If the probability factor and  $N$  remain constant, we have simple exponential growth such as shown by Fig. 1(a). However, in some fields such as computers the number  $N$  may be changing itself, perhaps in an exponential manner (say,  $N_t = N_0 \cdot \exp. K't$ ).

Additionally, the probability factor may not remain constant and  $K$  may change. Again the likelihood of emergence of new information may decline in some areas and increase in some other areas because of various factors. So, if there is an upper limit of total information it might become increasingly difficult to unearth new knowledge. If mutual interaction amongst scientists is positive then the likelihood may increase with increase in number of scientists. It is also possible that beyond a certain number of scientists the performance of the individual declines. All such possibilities would complicate the actual relationship between  $I$  and  $t$ . We can think of

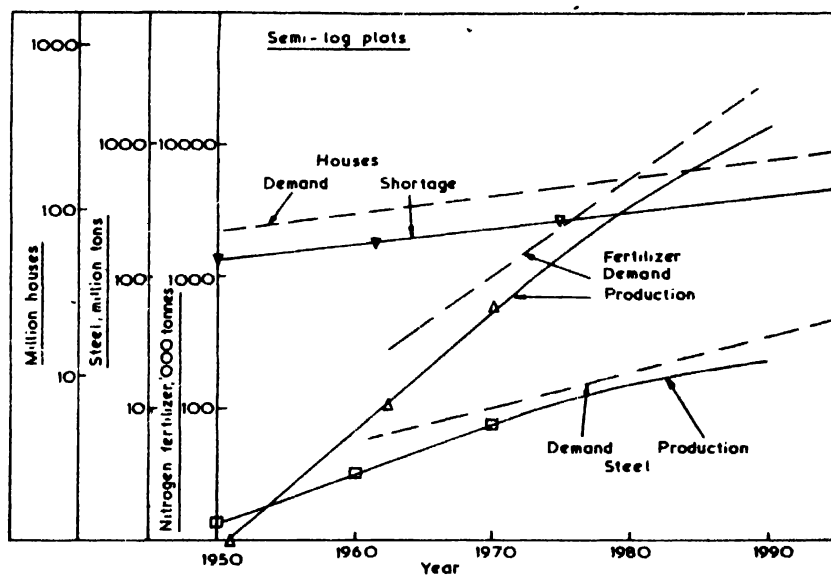


Fig. 3. The persistent shortage

similar complications in all the examples considered previously.

### Technological forecasting

The aim of technological forecasting is to analyse trends and make long term projections on some rational basis. Such forecasts, known as heuristic forecasts, often make use of the simple exponential growth eq. (4) which gives a linear plot on semi-log paper. A plot of the logarithm of the variable versus time should give a straight line. If the linearity holds for a prolonged period in the past and the present then one can extrapolate the straight line plot with some measure of confidence.

S. Bowonder and P. K. Rohatgi have written an excellent article on the subject of technological forecasting with special reference to India and some of their data are summarised in Fig. 2. The figure shows that the data for several variables such as production of pig iron per year, grain, electric motors, fertilizers and air travel passengers do follow the exponential growth law and, accordingly, give linear plots on the semilog graph paper. It

seems reasonable to extend the linearity for heuristic forecasts in some cases at least.

There is also a prominent exception. Although the Indian iron and steel industry grew exponentially in the initial years after independence the rate of increase dropped subsequently, the setback being particularly pronounced after 1965 Indo-Pak war. The change in the trend and drop away from the exponential growth line seems to have been a permanent feature.

### Increase in demand

In the preceding paragraph we have discussed the exponential growth in the supply of some commodities. Such growth may, at first glance, indicate a happy situation. However, it should be noted that with the passage of time the population grows, the industry expands and, consequently, the demand also continues to increase. This increase is also often exponential because of a constant rate at the unit level. It is, therefore, often the case that in spite of an exponential growth there remains a persistent gap between demand and supply. Some data for India, again



summarised from the data of Bowonder and Rohatgi, are shown in Fig. 3. The figure shows that even if the production of fertilisers, steel and houses continue to increase in the exponential manner there would remain a permanent shortage which may even keep on increasing with time.

#### Some implications of the exponential growth and exponential decay laws

Exponential laws where the rate of change increases steadily have important implications. Firstly, in such laws the change at any instant is defined in terms of the total value of the variable at that instant. So if literacy rate in the country is to be improved exponentially then it can only be achieved by mass participation. Starting from a few nuclei of teachers it must spread by illiterates becoming literate and then participating themselves in the teaching process. Leaving the job to a few agencies will not do. In fact, if this is the case then chances are that the in-

crease in the number of literates may creep up slowly but per cent literacy may drop significantly. In other words, the number of people born every year exceeds the number of people taught to read and write. This has actually happened. If athletic activities are to spread then every athlete must induce others thus being a vehicle of transformation himself.

Secondly, if there is a persistent lag between demand and supply then only a significant difference in the basic rate constants ( $K$ ) can bridge the gap. The basic rate of increase of demand must be lowered and that for the supply increased. This is generally far easier said than done particularly if the demand grows because of population growth. The gap can be bridged only by drastic changes in the trends by such methods as widespread and effective family planning, real technological breakthroughs and long term national planning. Bowonder and Rohatgi have pointed out that India has to provide housing to the majority of

the population by the year 2000, every year more than 5 million houses have to be built. India will not be able to build all these houses using steel reinforced concrete structures even if all the steel produced between now and then is used for housing alone. It is therefore imperative that all other possible alternatives in building materials are tried out extensively. In fact, in India, continued shortage of the basic items in many areas is obvious unless newer and alternate sources are developed, technological breakthroughs are made and a sense of thrift is introduced to minimise the levels of consumption.

#### Further reading

1. Ayres, Robert U., *Technological Forecasting and Long Range Planning*, McGraw Hill Book Company, NY (1967), Ch. 7.
2. Bowonder, S. and Rohatgi, P. K., *Technological Forecasting and Social Change*, Vol. 7 (1975), p. 233.

## ANSWERS AND SOLUTIONS (See page 61)

### Science quiz

1.(ii), 2 (i), 3.(i), 4.(iv), 5.(iii), 6.(ii), 7.(i), 8.(i), 9.(ii)

### Brain teasers

1. The only three digits which give superimposable mirror images are 1, 8 and 0. Since the mirror image of the page number was an exact replica of itself it must have comprised only these digits. Further since Rajnikant opened the fourth volume of the book, the page number must have been between 1501

and 2000. The only four-digit number in this range which also fulfils the conditions laid down in the problem is 1881. This, therefore, gives the required page number.

2. The total number of eggs in the basket must be between 12 and 60. Also, when turned upside down, it must be a readable number. Only three such numbers are in the range 12 to 60 namely, 16, 18 and 19. Different pairs of digits that add up to 16, 18 and 19 are respectively :

16 : 7,7; 8,8  
18 : 7,11; 8,10; **9,9**

17 : 7,12; 8,11; 9,10

Of these pairs of digits, the first digit in each pair gives, say, the number of white eggs and, the second digits, the number of brown eggs. These numbers, as stated in the problem, must exceed 6.

It is now easy to see that 18 is the desired number which gives the total of the eggs. Its inversion is 81 which is equal to the product of the two digits (9,9) that have been printed in bold types above. It follows that the basket contains nine white and nine brown eggs.

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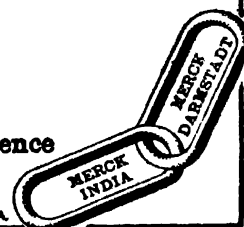


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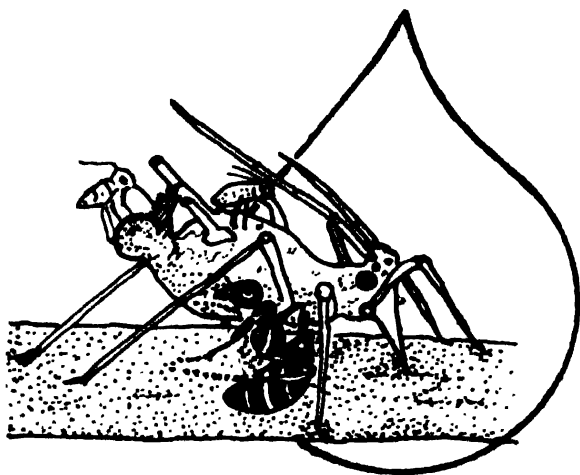
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# HONEYDEW

## a food by insects for insects

**A sugary fluid excreted by certain plant-sucking insects, honeydew is a complex mixture of nutrients including free amino acids and amides, proteins, minerals and B-vitamins**

**S. P. KURL**

**P**EOPLE know about 'honey', 'honeybee', 'honeycomb' and 'honeymoon' too, but not honeydew. The dictionary meaning of honeydew is: sweet, sticky substance found on leaves and stems, excreted by aphids (Insects : Homoptera). More precisely, honeydew refers to the liquid droplets exuded from the anus by aphids, coccids and many other plant-sucking insects. It was customary to refer to 'mannas' as plant secretions and 'honeydews' as secretions produced by insects. Sweet plant secretions other than nectar do exist, but many of the early so-called mannas seem to have been produced by insects.

From very early times, deposits of honeydew (and manna) on or near plants have attracted much interest, especially because of their high sugar content. The manna or sugary honeydew excreted by aphids

and scale insects is used as a sweet by peasants in Turkey, Iraq and Iran. According to F. S. Bodenheimer and E. Swirski (1957) of Iraq, about 31,752 kg manna is collected and sold in Iraq annually. In Australia, Chermid honeydew is collected as food by the aborigines. Referred to as 'sugar-lerp', upto 1.5 kg of honeydew can be harvested by one person in a single day.

### **Honeydew and manna**

The excreta of the plant-feeding Homoptera, particularly aphids and coccids, are specially interesting not only because of the relatively enormous amount produced—as much as several times the weight of the insect in 24 hrs—but also because of the extremely high carbohydrate content which may exceed 80% of the total weight of the fresh

excreta. These excreta are very attractive to other insects and are termed honeydews (liquid) or manna (crystallized honeydew). The excrement is a clear fluid. In aphids and coccids it contains much unabsorbed organic matter, particularly carbohydrates, and furnishes the 'honeydew' that collects on the leaves of plants in dry weather. The manna is a similar product from the coccids. It contains 55% of cane sugar, 25% of invert sugar and 19.3% of dextrin.

Recent studies have demonstrated that fresh honeydew is usually a complex mixture of a large variety of chemical compounds, including several sugars, amino acids and amides, organic acids, alcohol, auxins, salts, etc.

Many homoptera secrete a sweet, sticky fluid, often in such quantities, when the insects are in

abundance, that in falling it makes a noise like fine rain. Sticking on leaves, fruits or bark, it adheres and dries, serving as a medium for the growth of sooty mould—blackish fungus which spoils vegetables, giving to such places a sooty appearance. This secretion appears to be produced most abundantly by the soft scales, white flies, plant-lice, jumping plant lice and some of the treehoppers.

Honeydew is also secreted by leaf hopper, *Pyrrilla*. In sugarcane the leaf surface gets covered with the material which attracts a number of other insects and encourages the growth of a kind of sooty mould. The result is that the whole crop gives a blackish, unhealthy appearance, the utilization of the sunlight is hindered and considerable decrease results not only in the yield of sugarcane per hectare but also in the sugar recovery and in the quality of sugar recovered.

Aphids feed on the phloem sap of plants, rich in sugars but poor in amino acids essential for aphid's growth. They have to ingest enormous volumes of plant juice in order to be able to acquire sufficient protein. The residual solution of digested food, mainly sugars, is stored in the dilated rectum before ejection to the exterior in the form of a droplet of honeydew (Fig. 1). In aphids, honeydew contains about 11% dry matter of which 88% is carbohydrates and 7% nitrogenous compounds. Honeydew of aphids has the maximum nitrogenous content as compared to the excreta of other insects and man (Table 1).

Among aphids the frequency of excretion varies from 1.7 to 20 droplet(per aphid per 10 hr), the diameter of droplets varying from fractions of 1 mm to 1.5 mm. The frequency and rate of excretion may vary considerably between species. The frequency of excretion decreases gradually from the first instar to the adult. Some species excrete from

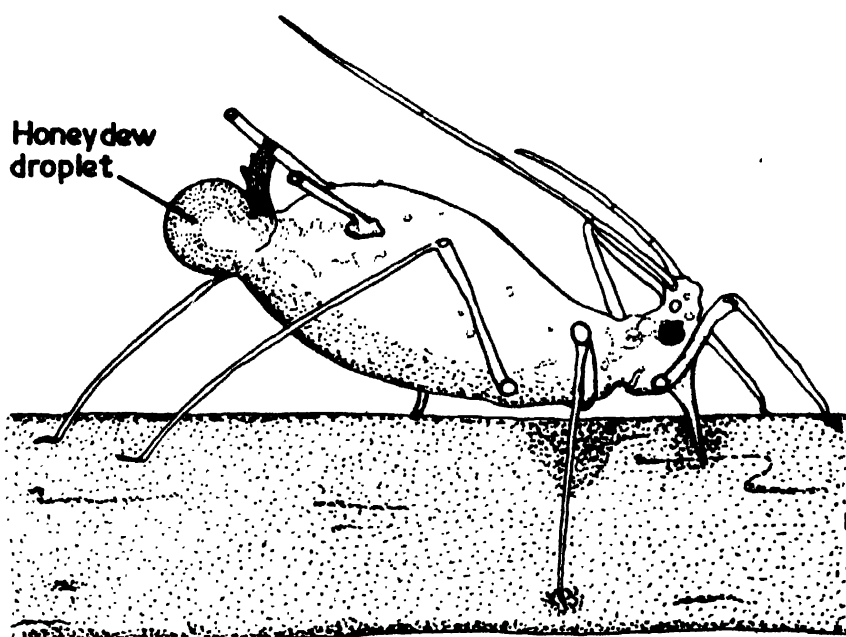


Fig. 1. Aphid excreting a droplet of honeydew

33% to 133% of their own body weight per hour depending on instar. The frequency of excretion alone does not necessarily represent a good comparative measure of the quantity of honeydew excreted. Regular honeydew excretion is interrupted by moulting, and may cease momentarily at other times during the nymphal and adult life of an aphid.

It is generally assumed that aphids deprived of food cease to excrete, although a much reduced excretion may occur during a few hours of starvation. The species, variety, part and growth stage of the host plants fed upon may influence honeydew production. No significant difference

in frequency was observed whether aphids fed on flowers, buds, or vegetative branches, but the frequency was higher on leaves and stems than on petioles.

#### Collection of honeydew

Collecting sugary fluids is a very ancient habit of ants. Some ants depend more on honeydew than others. At one end some species are said only to lick up fallen honeydew from the leaves of plants, while at the other, a few are totally dependent on their own species of aphids kept in their own nests. Some ants visit plant-lice in the open air

Table 1. Composition of nitrogenous excreta of insects and others

Constituent	Housefly	Mosquito	Aphid	Moth	Man
	% of total nitrogen				
Uric Acid	36.2	43.3	0	47.2	1-3
Urea	3.7	11.9	0	0.5	80-90
Ammonia	1.3	6.4	5-8	13.2	2.5-4.5
Amino N	7.4	4.4	90		2-6
Protein	0	10.8			Trace

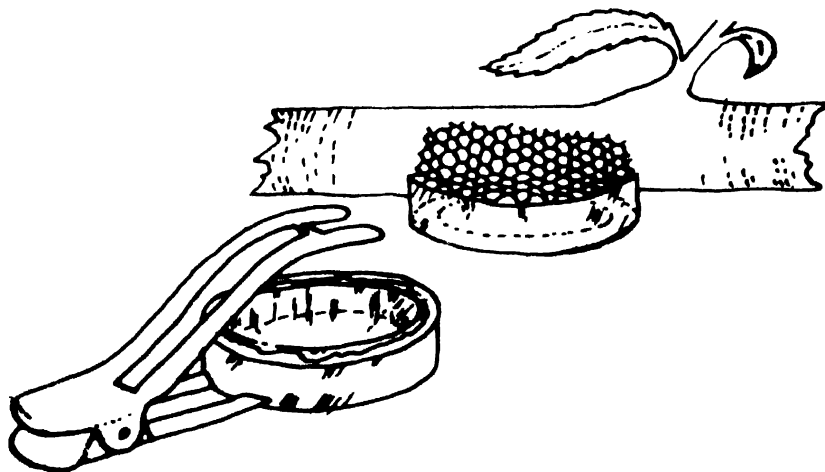


Fig. 2. The cage for the collection of honeydew

on plants some distance away from their nests. Wood ants, for instance, visit 65 species of aphids and may travel as much as 100 metres to reach them. A large aphid can produce upto 1.7 cu. mm of honeydew an hour. An ant colony can collect about 6 kg of honeydew from aphids in 100 days.

For scientific study of honeydew, the latter may be collected by using a cage (Fig. 2). The aphids are kept in cages manufactured from Perspex rings of 12 mm internal diameter and 5 mm thick. One ring is fixed to the sapling stem and muslin is applied between the upper surface of the ring and the stem. Honeydew is collected in aluminium foil cups of known weight held flush against the lower surface of the Perspex ring. The area of stem available for insect feeding is approximately 1 cm<sup>2</sup>. During honeydew collection, the saplings are held horizontal so that any honeydew produced falls into the aluminium foil cup. The aluminium foil cup containing honeydew is replaced every 24 hrs and dried to constant weight at 40°C.

#### Chemical constituents

Most of the higher sugars present in the honeydew are synthesized

enzymatically by the insect from the simple sugars glucose, fructose and sucrose found in the plant sap. The honeydew of aphid *Tuberolachnus* contains sucrose, fructose, glucose, the trisaccharide melezitose and various other oligosaccharides, all of which are derived from the action of invertase on the sucrose of the plant sap. The hexose residue split from the sucrose in the diet is not transferred exclusively to water as in chemical hydrolysis, but combines with other sugars present to produce various oligosaccharides, glucosucrose,

fructomaltose, etc. This 'transglucosidase' activity of invertase is found in many other insects besides aphids and coccids.

Chemical analysis of honeydew indicates its high sugar content as well as the presence of melezitose as a carbohydrate constituent, and of nitrogenous compounds. The word 'melezitose' (named after the French *milze* for larch) was first used by the French Chemist M. Berthelot in 1859 to describe a new sugar isolated from *manna de Briancon* secretion collected on larch trees in the French Alps.

Amino acids remain unchanged during passage through the gut of an aphid, whereas sugars may be partially converted by aphids and coccids to melezitose (Fig. 3). In some aphids there appear to be two  $\alpha$ -glucosidases with different acceptor specificities to different ends of the sucrose molecule. The effect of one is to add glucose to C-4 of the glucose in the sucrose to form glucosucrose, while the effect of the other is to add glucose to the C-3 of the fructose in sucrose to form melezitose. A rise in temperature from 20°C to 25°C or a light wind of 2.5 kph may increase the sugar concentration slightly, probably as a result

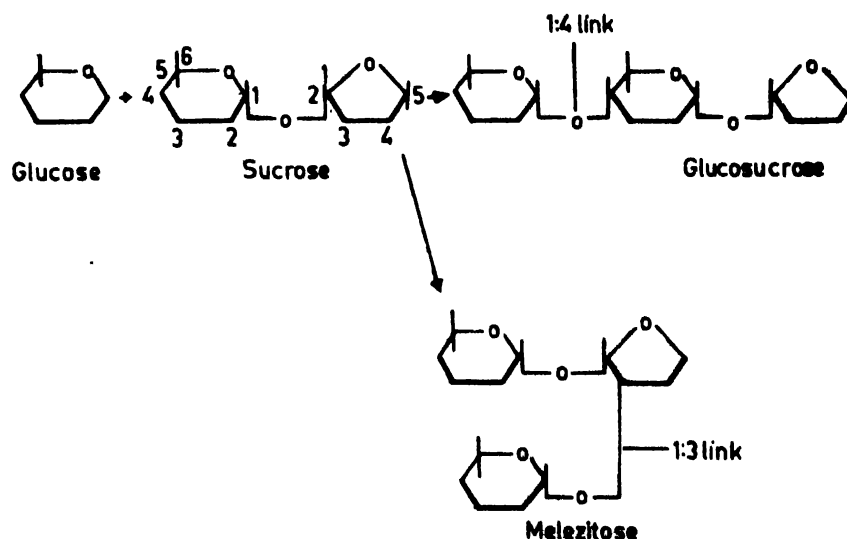


Fig. 3. Two types of oligosaccharide synthesis in the gut of aphids

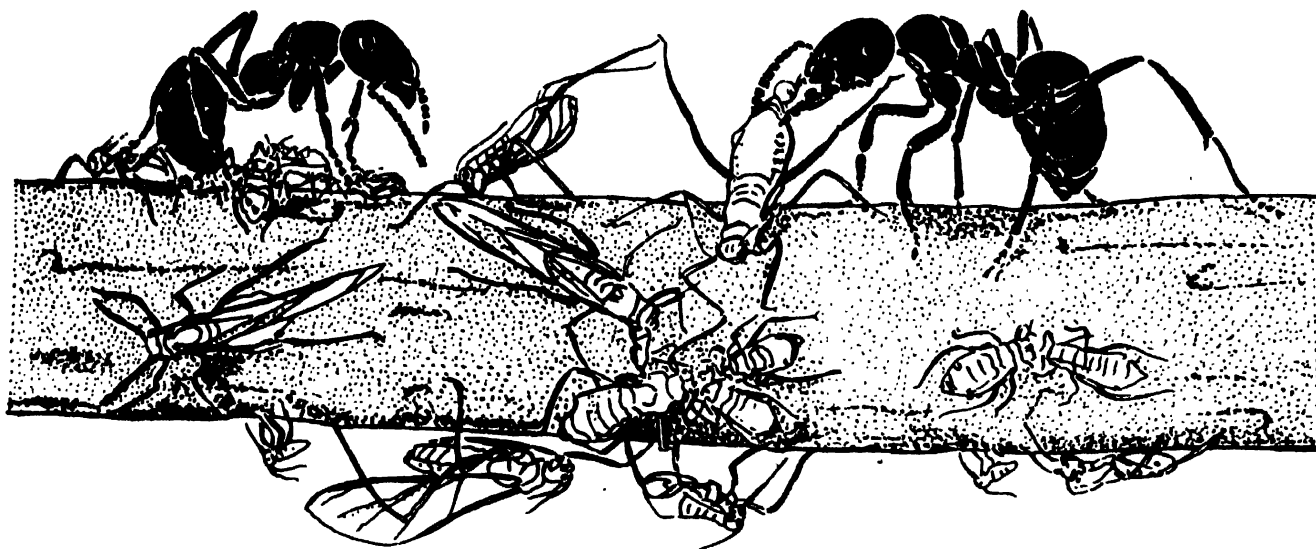


Fig. 4. Workers of ant, *Formica* sp. attending aphids. Note the imbibing of honeydew droplet by ant

of an increase in water evaporation from the aphid's body, although changes in the plant carbohydrate metabolism affecting honeydew sugar content cannot be ruled out.

The results of qualitative paper chromatographic analyses of sugars in honeydews show that fructose, glucose and sucrose are generally present, together with a few oligosaccharides such as melezitose and the glucosucrose (fructomaltose) series. The simple sugars fructose, glucose, sucrose and glucose-1-phosphate have also been reported from extracts of many of the host plants. The presence of invertase in the aphid gut strongly suggests that hexoses in honeydew are mainly digestion products so long as the aphids are tapping sieve-tube elements.

The various oligosaccharides of honeydew can be regarded mainly as products synthesized from simple sugars through gut invertase action. By the use of dyes and radioactive components in the diet, it has been confirmed that in Jassids (leaf-hoppers) most of the water and sugars pass by way of the filter epithelia to reach the hind-gut by the short route and are rapidly eliminated as honeydew. The amino acids and proteins remain in the digestive tract.

The presence of nitrogenous compounds in the honeydew was established only in the sixth decade of the present century. Some 9-23 amino acids and amides are of general occurrence in the honeydew of aphids. Twelve compounds occurring frequently include alanine, asparagine and aspartic acid, glutamine and glutamic acid, the leucines, phenylalanine, proline, serine, threonine and valine, all of which are also reported free in the phloem of many plants. On the other hand, at least five amino acids, viz., tyrosine, histidine and some unidentified amino compounds are reported to be present in coccid's honeydew while they are absent in the food source.

Aphids feed on the phloem sieve tube juice which exists under pressure in the plant and can be controlled by cutting through the embedded stylet-bundles after they have been inserted by the insect. The amino acids excreted in the honeydew are in much lower concentration than they are in the sieve tube juice. The phloem juice of bean, *Vicia faba*, contains 19 amino acids or amides, no peptide or protein and has a total nitrogen content of 0.24%. The honeydew from aphid *Megoura* sp. feeding on this juice contains all the

same amino acids but in reduced concentration, with a total nitrogen content of 0.11%. There are some extra amino acids, viz., tryptophan and histidine.

Besides carbohydrates and nitrogenous compounds, there are some other compounds present in honeydew. Citric, malic, succinic, fumaric, isocitric and pyrrolidone carboxylic acids, disodium citrate, phosphate, nitrate, chloride and sulphur have also been reported from honeydew in very negligible amounts. In some cases dulcitol, ribitol, inositol, adinotol and sorbitol are also detected. Auxins such as 3-indoleacetic, indolebutyric and indolepyruvic acid-ethyl-1-3-indoleacetate and 3-indoleacetonitrile have also been reported from honeydew of aphids feeding on wheat and barley.

The implication that honeydew may be a complete food is supported by the evidence that it is not merely a solution of sugars but a complex mixture of nutrients including free amino acids and amides, proteins, minerals and B-vitamins.

#### Honeydew and ants

The relation of ants to aphids is most interesting as honeydew is an

important part of their diet and in some cases it may be their only food. There is every evidence that the benefit is mutual; the ants protecting the aphids, driving away the enemies or carrying them to the protected places. Ants that care for root-feeding aphids keep them in underground chambers or galleries, conduct them to their sources of food supply, collect and store their eggs for the winter, and in the spring take the young to their food. Similarly, scale insects that produce honeydew are also cared for in a sense, for ants are very attractive to them and to an extent prevent them from enemies by their presence and activity.

Although the evidence that an intimate bond exists between certain aphids and certain ants is fairly clear, the ant's capacity for animal husbandry has been much exaggerated. Ants do not herd the aphids like cattle. The aphids form herds of their own, sometimes numbering 80 to 100 individuals, whether or not ants are present. Usually when an ant is observed carrying an aphid off in its jaws, the ant is not taking the aphid to greener pastures but bringing it back to the nest to be used for meat rather than sugar.

The means by which ants obtain honeydew from their aphids was first fully described by an English scientist, Pierre Huber in 1810. Symbiotic homopterans ease out the droplets of honeydew when solicited by ants, rather than ejecting them at a distance. Individuals of black bean

aphid show the following typical specialized responses in the presence of ants. Their abdomen is raised slightly, the hind legs are kept down instead of being lifted and waved as in unattended aphids, and the honeydew droplet is emitted slowly and held on the tip of the abdomen while it is being consumed by the ant (Fig. 4). If a droplet is not accepted, the aphid will often withdraw it back into the abdomen. The extreme myrmecophilous aphids (aphids in close association with ants) have acquired a circlet of stiff hairs around the anus, called trophobiotic organ, that serves to hold the honeydew droplet while it is being eaten by the ant.

The way by which the ants get honeydew from aphids is well known now. Ants collect honeydew by touching the hind end of the aphid repeatedly with their antennae until a droplet appears. This time the aphid does not throw it away but holds it on the tip of its abdomen. The ant sucks it up at once and goes to another aphid for more. When there are no ants, the aphid gets rid of the honeydew drop by kicking it away or by throwing it away with the cauda—an elongated point at the tip of its abdomen. Some scale-insects which have short legs and no cauda can squirt honeydew to about 5 mm from their rectum. Aphids, which are attended by ants, produce smaller droplets more often and usually only when an ant touches them.

It has been shown that the solici-

tation can double or treble the normal rate of uptake of phloem sap and hence the rate of excretion of honeydew by aphids. This may or may not increase the rate at which amino acids are assimilated by the aphids, it seems certain that when attended by ants they assimilate a small proportion of the amino acids and less sugar during rapid flow of sap through their gut.

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## SOLAR ECLIPSE (Continued from page 8)

as they are non-metallic filters and do not effectively cut off ultraviolet rays. No filters are, however, required during totality.

For seeing a projected image of the sun during partial eclipse one can try a few simple arrangements as follows:

Take an aluminium foil or a piece of card-board with a pinhole of

1 mm diameter and allow the sunrays to fall on a white surface kept at a distance of 1 metre from it under shade. A fairly clear image of the sun is formed on the white surface. A better arrangement, however, is to cover a plane mirror with a piece of paper having a circular hole of diameter 1 to 2 cm. The sunlight reflected from this arrangement may

be thrown on to a shaded wall indoors to give an image of the partially eclipsed sun. Reduction in the diameter of the hole in the paper will increase the sharpness of the image but its brightness will be less.

(Source : Positional Astronomy Centre, India Meteorological Department P-546, Block 'N' (1st Floor), New Alipore, Calcutta-700053)

# SCIENCE SPECTRUM

## Telecommunications experiment through Symphonie

by providing necessary inter-connecting equipment and accessories which can match the terrestrial system circuits with the system circuits used in satellite links. Indian experts also felt that for indigenous development of hardware needed in linking the domestic circuits with a satellite, a detailed know-how of the technology involved in design, fabrication and production of the electronic and other associated equipment to be used with satellite was essential.

To gain know-how and establish such a hybrid system of satellite-oriented telecommunication network in the country, the Indian Space Research Organisation (ISRO), the Overseas Communication Service (OCS), the Post and Telegraph (P & T) Department and the Doordarshan have made coordinated efforts in the last few years. Various projects such as the installation (in 1971). operation and maintenance of Vikram Satellite Earth Station (VSES) at Arvi; the design and fabrication of the Aryabhata satellite and its launching from the Soviet cosmodrome in 1975 and the Satellite Instructional Television Experiments (SITE) in 1975-76 (S.R., August 1975) were undertaken. The second earth station for satellite communication, the Ahmed Earth Station at Dehra Dun, was also commissioned in 1977.

Besides, the Franco-German "Symphonie" satellite was used for

**R**IGHT from the early ages efforts have been made to bridge the communication gap. First came telephone, then radio and now are available satellites for telecommunication. With the advances made in the electronics and the associated technology, transmission of greater volume of traffic covering longer distances through satellite is now possible. The adoption of multiple access techniques has still further increased the role of satellites in communication. Using this technique different ground stations can have access to any satellite channel or channels simultaneously. The result is that any satellite channel can be had for the asking.

By virtue of their vast resources and the available know-how, the advanced countries have immensely benefited from this modern communication medium. Only a fraction of the benefits came in the share of less developed nations which could not afford such a system exclusively for domestic applications. Under such constraints, the less developed nations like India made use of the terrestrial communication network for meeting domestic needs.

With the increase in the overseas telephone traffic a need was felt in India to make use of those satellites of International Telecommunication Satellite Consortium (INTELSAT) which are stationed in the synchronous orbit over the Indian Ocean. A hybrid system of communication—consisting of both terrestrial network and links via satellite—was considered by the Indian space scientists and engineers to be the most optimum and economically suitable for India. In this way the terrestrial telephone and other circuits available in the country could be fully utilised

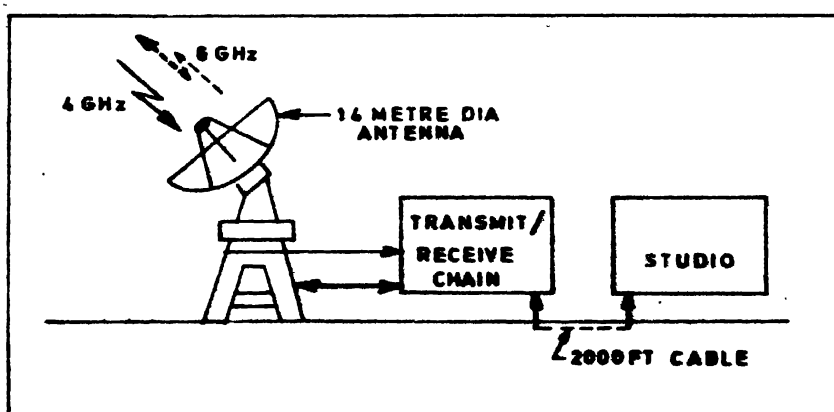


Fig. 1. Ahmedabad earth station with studio facility



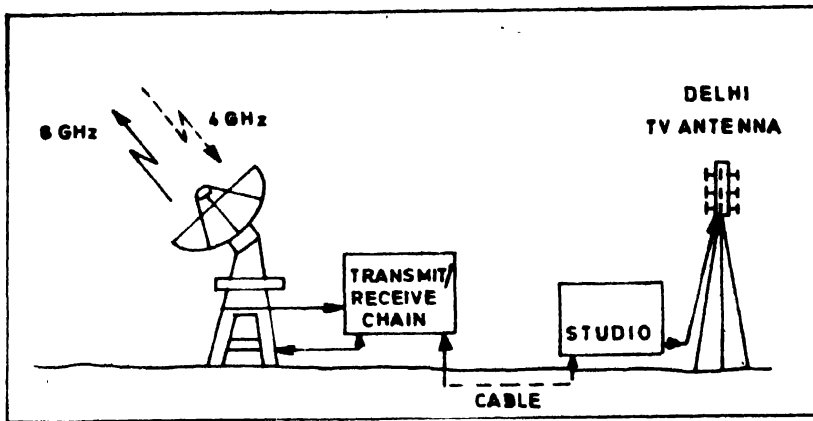


Fig. 2. Delhi earth station with studio facility

conducting various telecommunication experiments for two years beginning from June 1977. The project was called "Satellite Telecommunication Experiments Project (STEP)". It was a joint venture of Space Applications Centre of ISRO, Telecommunication Research Centre of P and T and Doordarshan. The Indian Telephone Industries (ITI) developed the necessary hardware required for conducting the experiments. The primary objectives of the STEP were to gain experience in the design, development, installation, operation and maintenance of

the ground equipment required for satellite communication.

During the project three main satellite communication earth stations at Ahmedabad, Delhi and Madras were used. Besides, two mobile terminals, which could establish links via "Symphonie" satellite, were also put into operation. One of the terminal, 'Transportable Remote Area Communication Terminal' (TRACT), was built on a large truck chassis with a collapsible antenna structure. This terminal was deployed at several places in the country like Amreli in Gujarat for linking

telephone circuits and telecast TV programmes; Ajmer and Gangtok for telecast of special programmes. The most important application of this terminal was the live telecast of the Indo-Pak cricket test matches held in 1978 at Faisalabad, Lahore and Karachi. The terminal was also used for connecting telephone circuits of a small place with the trunk automatic network existing in a city. A person from a remote village with telephone facility was thus able to talk directly to a person in a city without any delay. This was achieved by the use of special digital techniques for processing of signals via satellite. In these techniques signals are represented by sequences of numbers or symbols.

A smaller version of TRACT, known as 'Emergency Communication Terminal' (ECT), was used for providing emergency communications in such areas where other communication network had failed due to some natural calamities. This terminal was deployed in Vijayawada in November, 1977 for giving information via the satellite to Delhi about devastation caused by the cyclone. It enabled All India Radio to broadcast spot-news over its network. A 'Seminar via Satellite', in which many communication engineers and scientists participated, was also conducted.

With the successful completion of STEP, India has crossed yet another milestone in its journey towards the launching of indigenous communication satellites under the Indian National Satellite (INSAT) programme. The experience so far gained in the above project will be instrumental in indigenous development of hardware for ground system. It is envisaged that these major projects will form the foundation and enable India to harness the vast potential of space technology for the benefit of its millions in the foreseeable future.

P. I. BAKSHI

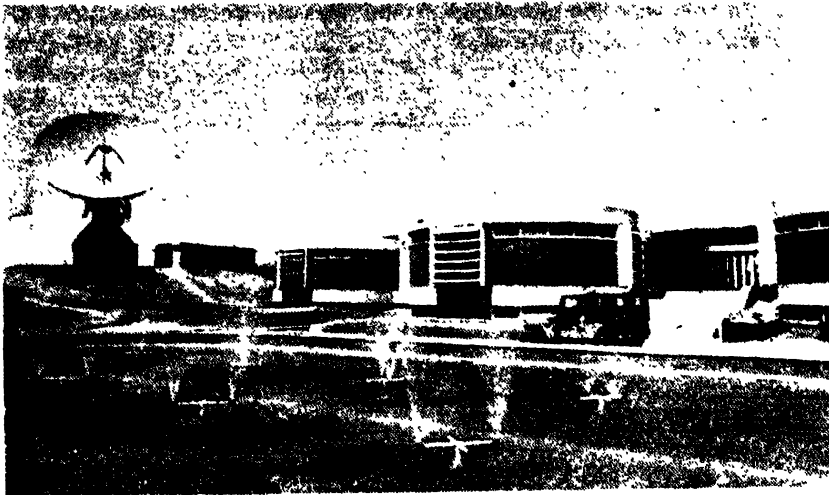


Fig. 3. General view of Experimental Satellite Communication Earth Station (ESCES), Ahmedabad

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**SHANTI SWARUP BHATNAGAR PRIZE FOR  
SCIENCE AND TECHNOLOGY  
FOR THE YEAR 1980**

Nominations are invited for the award of Shanti Swarup Bhatnagar prizes for 1980. The Shanti Swarup Bhatnagar Prize is the highest and most coveted award amongst the Scientists and Technologists in India. This award was instituted in 1957 by the Council of Scientific & Industrial Research in the memory of its first Director and Architect, late Dr. Shanti Swarup Bhatnagar and is made each year for outstanding contributions in Science including Engineering and Technology. The award is for research contributions made primarily in India during the five years preceding the year of the prize. Only Scientists/Technologists who are upto 45 years of age are eligible for consideration.

Five or more Prizes, each of value of Rs. 20,000/- may be awarded annually for notable and outstanding research, applied or fundamental, in the following disciplines:

1. Physical Sciences; 2. Chemical Sciences; 3. Biological Sciences; 4. Mathematical Sciences; 5. Engineering Sciences; 6. Medical Sciences; and 7. Other Sciences.

To decide about the Prizes, the Council invites and accepts nominations each year from the Presidents of approved Scientific Societies of all-India character, Vice-Chancellors of universities, Deans of Science, Engineering & Technology, and Medical Faculties, Directors of IITs, Deans of Faculties and heads of Institutions deemed to be of University status, Director-General of major R & D Organisations, such as DRDO, ICAR, ICMR, Chairmen of AEC, UGC, Space Commission, ONGC, etc., Directors of CSIR Laboratories and BARC, TIFR, etc., and the Bhatnagar Prize Awardees. University Faculties should recommend persons working in their institutions only and route it through their respective Vice-Chancellors while the Faculties in IITs should send their nominations through their Directors. The Directors of CSIR laboratories can nominate a candidate in the discipline of their interest, irrespective of whether they are working in CSIR laboratories or outside. Each Bhatnagar Prize Awardee can send nomination of one person for each-year's award in his own discipline only. Each such nomination shall give detailed statement of work and attainments of the nominee, and a critical assessment report (not more than 500 words) bringing out the importance of the significant research and development contributions of the nominee made during 5 years preceding the year of the Prize. Nominations from individuals sponsoring their own names or of others are not accepted.

The nominations may be sent by Registered A.D. Post along with 10 copies of detailed statements of work and attainments of each nominee and the discipline under which the nominee is to be considered. The attainments of the nominee during the past 5 years may be highlighted, and sent along with at least one set of reprints of papers published during the 5 year period. The nominations signed by the sponsors should be sent marked 'Confidential' to the Head, Extra-mural Research, CSIR, Rafi Marg, New Delhi-110001 and should reach CSIR, latest by 31 March 1980.

The regulations governing the Prize and the proforma for nomination may be obtained from Head, Extra-mural Research, CSIR, Rafi Marg, New Delhi-110001.

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## Autographs of molecules

**R**ADIOAUTOGRAPHY, also known as autoradiography, is a most fascinating technique for investigating the mysterious behaviour of various living and non-living constituents within the cell and in its organelles. As the term suggests, in this technique molecules leave their "autographs" or "signatures" from wherever they pass in the form of black dots formed due to the reduction of silver grains by ionizing radiations emitted by radiolabelled molecules.

An ordinary molecule is radiolabelled by incorporating radioactive isotope of one of the constituent atoms of a molecule. Those atoms which differ in number of neutrons from ordinary atoms and have a nucleus which disintegrates continuously, emitting ionizing radiations (alpha, beta, gamma rays, etc.) are known as radioactive isotopes. Radioactive isotopes are produced by bombarding ordinary matter with high energy particles in accelerators or with neutrons in reactors or as a result of nuclear fission. Radioactive isotopes were first introduced as an investigative tool in biological research by the Hungarian chemist G. H. Heves in 1923, who studied circulation of lead in plants by using radioactive lead. But the scope of these studies were limited at that time due to the non-availability of radioactive isotopes suitable for incorporation into living systems, because the only radioactive substances known then were Uranium and Thorium occurring in nature, and these are not natural constituents of animal or plant tissues. A breakthrough came in 1938 when the fissioning process of Uranium was discovered with the subsequent development of nu-

clear reactors in which very large amount of artificial radioactivity can be produced. But the greatest impetus came through the discovery of Tritium ( $H^3$ ), the radioactive isotope of hydrogen, by the American scientist P. J. Fitzgerald in 1950. Since then tritium has been used extensively by biologists in solving various physiological puzzles in living systems, because hydrogen is a normal constituent of all living organisms.

The basic principle of autoradiography is similar to that of photography. But, here the role of light is played by ionizing radiations such as alpha, beta and gamma rays, which are continuously emitted from radiolabelled atom. The radioautography emulsion contains cry-

stals of silver bromide which are ionized due to these radiations. Then the action of developer reduces silver bromide to silver, forming black dots which are visible under the microscope (Fig. 1). These are the dots which indicate the presence or absence of radiolabelled atom in cells or its organelles and the analysis of their temporal and spatial relations yield all the necessary information for scientists.

The organ or tissue which is to be investigated is provided with such a molecule which it readily takes up and one atom of this artificially introduced molecule is radiolabelled. The radiolabelled compound is then injected in the experimental animal. After the necessary time interval, which depends upon the type of investigation, the animal is sacrificed and the desired tissue is removed. This tissue or organ is then hardened by putting it in a fixative for a fixed time, which varies according to the nature of

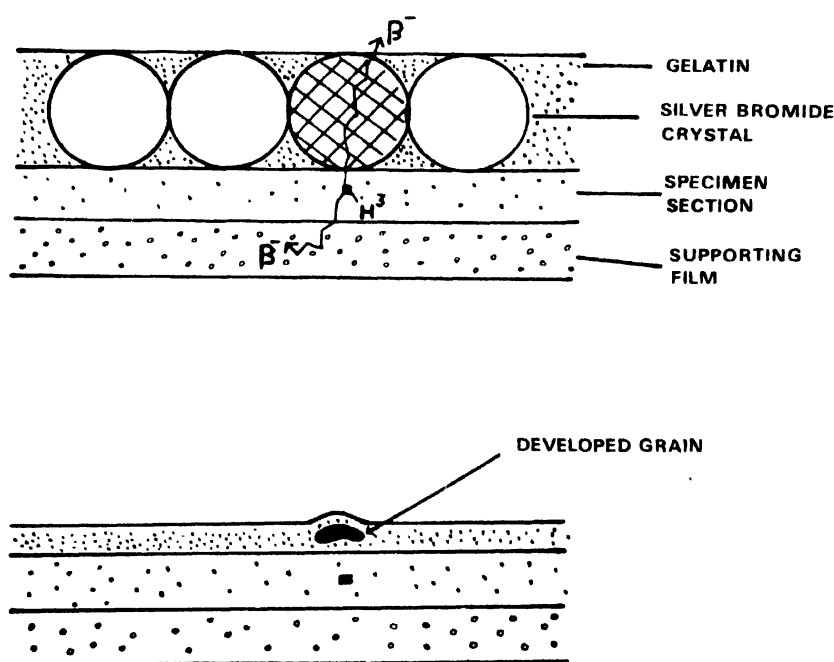


Fig. 1. Diagrammatic representation of an electron microscope autoradiograph preparation. Formation of a latent image on surface (black spot on upper left region of crystal) during exposure (top); Development of the exposed crystal into a filament of silver after processing (bottom)

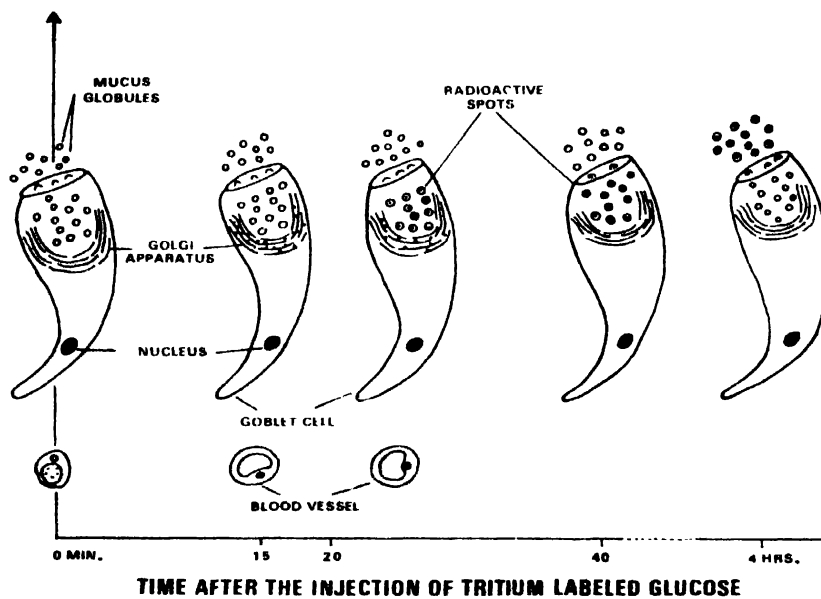


Fig. 2. Diagrammatic representation of the results obtained by combined radioautographic electronmicroscopy studies of the goblet cells of the intestine showing the stages in the synthesis of mucus globules after injection of tritium labelled glucose

tissue and the investigation to be carried out. Paraffin blocks of the tissue are then cut with a machine called microtome so as to get very thin sections ( $1\mu-5\mu$ ,  $1\mu=1/1000$  mm) which are then processed further as for ordinary histological preparations. Slides containing the labelled tissue sections are dipped in a special radioautographic photo-sensitive emulsion contained in a specially designed slot-shaped flask. Then the slide is dried, put in a light-tight-box and kept in the refrigerator for exposure. Unlike the exposure time necessary in ordinary photography, here the exposure time varies from days to weeks or months. This is because the minute quanta of ionizing radiations within the tissue sections take a long time to blacken the infinitesimal silver grains in the emulsion. After exposure the slide is put in a developer and developed like an ordinary photographic plate. One can now easily see the dark dots

of silver atoms under the microscope; but to locate their exact position in cells, the slide is stained by a suitable histological stain to make clear the outline of the cell and its organelles.

Before the discovery of radioautography, like many other sub-cellular processes, the secretory process of mucus globules in the intestine was not clearly known. It was known that proteins manufactured by the ribosomes pass through the golgi apparatus and then come out in the form of glycoproteins (carbohydrate combined with protein) packaged in globules. So, to confirm the role of the golgi body in the carbohydrate-protein synthesis process, glucose labelled with tritium was

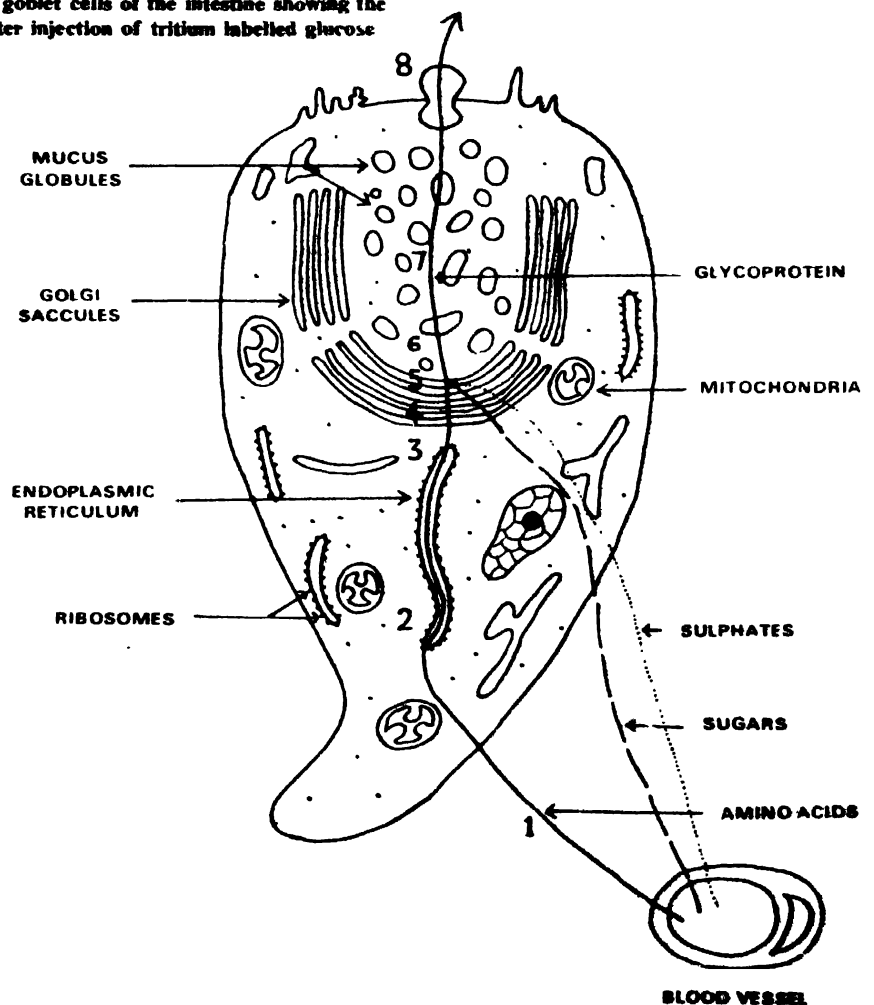


Fig. 3. Schematic diagram of the events in a goblet cell formation of m →

injected into young rats followed by radioautography of goblet cells of the large intestine.

Just after 15 minutes of injection all the radioactive dots were found in the golgi apparatus which indicated beyond any doubt that carbohydrate is stored in it immediately after incorporation. After 20 minutes, mucus globules containing radioactive glucoproteins begin to appear and after 40 minutes almost all the radioactive carbohydrate is found to have been removed from the golgi complex by the mucus globules (Figs. 2 and 4). It confirmed that protein and carbohydrate association takes place in the golgi apparatus (Fig. 3).

Radioautography has also solved many important and fundamental problems in genetics, for example, the 'duplication of chromosomes'. When a cell is ready to divide mitotically, each chromosome appears as a pair of threads called chromatids. During division chromatids separate and each member passes to the daughter cells so as to carry the original type and number of chromosomes. When this daughter cell is ready for division once again, each chromatid again appears with a partner. The puzzle was, whether this new chromatid is produced by the previous chromatid by acting as a template or by breaking down into smaller pieces which grew and re-

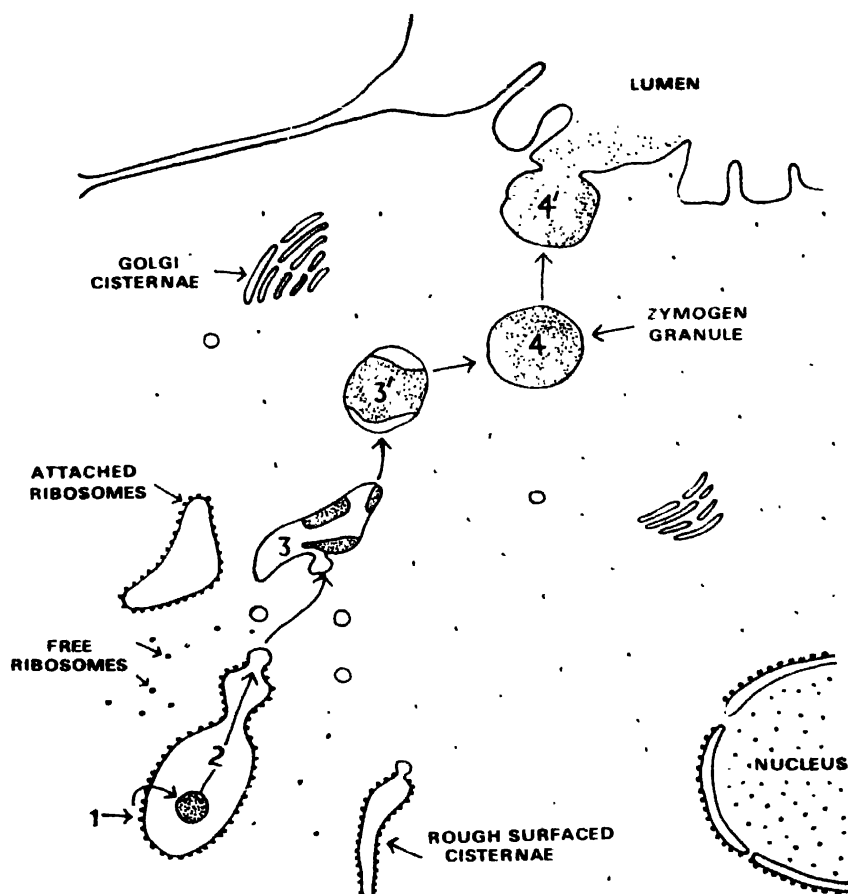


Fig. 5. Diagram of the secretory process in the pancreatic acinus, showing the different stages; 1-ribosomal stage; 2-endoplasmic reticulum stage; 3-3' Golgi complex stage; 4-Zymogen stage; 4'-release of zymogen into the lumen (intraluminal stage)

assembled, forming a pair of chromatids. To solve this problem, cells were cultured in tritium labelled thymidine (a component of DNA), and were treated with colchicine (a cell division inhibiting drug, which does not interfere with chromosome duplication) so that newly synthesized chromosomes can be identified easily. It was found that after the first duplication the radioactivity was distributed in all the chromosomes equally, which suggested that chromatids first broke down and then grew, forming new ones. But, when after the first duplication of chromosomes, cells were put in a non-radiolabelled thymidine cul-

ture, the radioactivity was found on only one partner of the second generation of chromosomes, which settled once and for all the fact that duplication of chromosomes takes place by the 'template' method.

Not only through light microscopy, but certain problems have also been solved by combining radioautographs with electron microscopy; for example, the secretory process of zymogen granules in the pancreas. In this case tritium labelled "leucine" was injected into experimental animals. After a few minutes the radioisotope was detected in the endoplasmic reticulum of the basal region of the pancreatic acinar cells, later

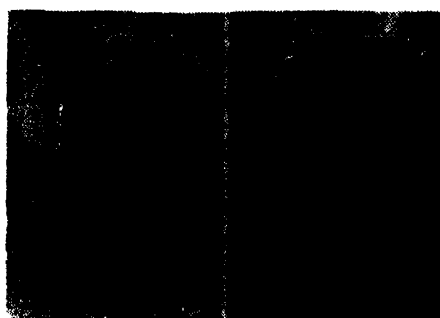


Fig. 4. Autoradiograph of intestine of a mouse injected with tritiated thymidine; (Left) animal killed eight hours after injection, (Right) 36 hours after injection (Tn, tagged nuclei, V, villus)

on the radioactive particles passed into the golgi complex, where they concentrated in the form of prozymogen grains. Finally the radioactivity was located in the zymogen granules, discharged in the lumen of the exocrine pancreas (Fig. 5). Its time sequence has also been worked out, and it has been found that in the endoplasmic reticulum it takes 4.7 minutes, in the proximal region of the golgi complex 11.7 minutes, and in the distal region of the golgi complex 36.0 minutes. Thus in the synthesis of zymogen granules the total time taken is 52.4 minutes.

Radioautography has made innumerable contributions to medicine, biology and agricultural sciences, and even an enumeration of all such contributions shall be too voluminous for this article. This is the technique by which the percentage of dividing cells in human beings was determined accurately and successfully. The data, that only 3% of the cells of our body are capable of dividing is of great significance in tissue repair studies. Death rate of cells was also calculated by radioautography. A number of medically important studies were made on pathogenic species of protozoa and bacteria. Physiologically important red and white blood cells have been studied in detail and their life span, rate of migration into the blood stream and rate of replacement in the body were also calculated. Radioautography has given us important clues regarding the origin and behaviour of malignant cells of cancer.

Radioautography is one of the best examples of the peaceful uses of nuclear energy. Its future prospects appear very bright indeed, as the following statement by two renowned scientists R. Baserga and W.E. Kisieleski reveal "we can think of it as a hybrid offspring of two

fields of 20th century research that have transformed the study of biology, biochemistry and the microscopic investigation of the anatomy of the cells. If the rule of hybrid vigour holds, radioautography should be-

come a very lively child indeed."

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## Polymer supported peptide synthesis

THE problem involved in peptide synthesis are of much importance and have received considerable attention. The major difficulty in putting together a chain of say 100 amino acids in a particular sequence is one of overall yield. At least 100 separate synthetic yield would be required and if the steps in each step were equal to  $n \times 100\%$  the overall yield is  $(n^{100} \times 100\%)$ . If the yield in each step were 90%, the overall yield would be 0.003%. A practical laboratory synthesis of a peptide of modest size should be carried out very efficiently.

Polymer supported peptide synthesis is a classical synthetic route which offers improved yields by minimizing manipulative losses that normally attend each step of a multi-stage synthesis. The key innovation is to anchor the C-terminal amino acid to an insoluble product and then add amino acid units by the methods used for solution synthesis. After the desired sequence of amino acids has been achieved, the peptide can be cleaved from the support and recovered from the solution.

One that is widely used is a cross-linked polystyrene resin of the type employed in ion-exchange chromatography. The resin should have loose structure to absorb organic solvents which can penetrate into the space between the chains. The resin is

chloromethylated using Friedel-Crafts reaction and the  $-\text{CH}_2\text{Cl}$  groups substitute in the 4-position of the phenyl group in the chain (Fig. 1).

At the start of the peptide synthesis the C-terminal amino acid is bonded through its carboxyl group to the resin by a nucleophilic attack of the carboxylate ion on the chloromethyl group. Next, the amine protecting group is removed and the next amino acid is coupled. The peptide bond forming steps are repeated as many times as needed to build up the desired sequence. Finally the peptide chain is re-

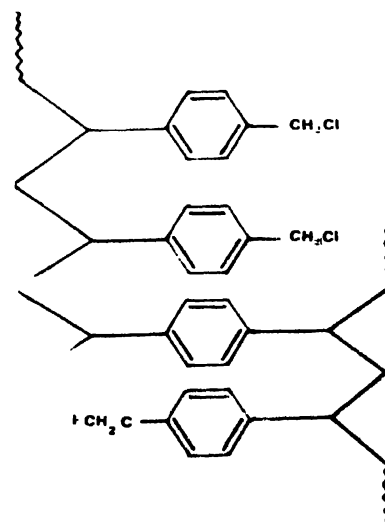


Fig. 1. Chloromethylated cross-linked polystyrene

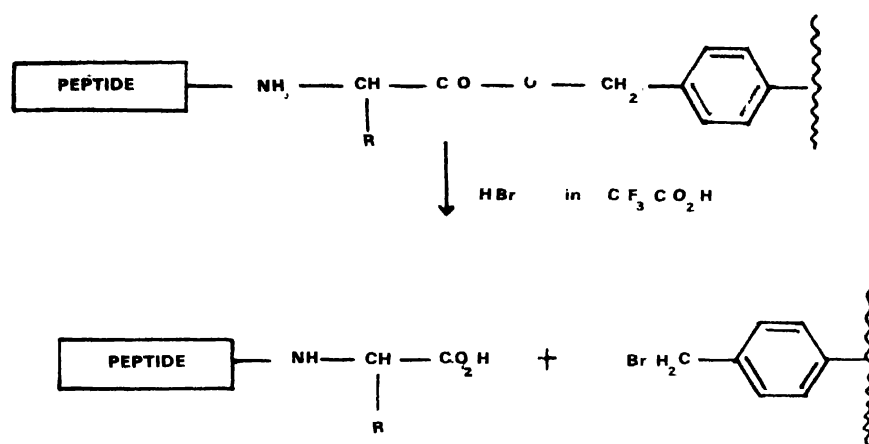


Fig. 2. Cleavage of peptide from the resin and loss of protecting groups.

moved from the resin, usually with HBr or anhydrous HF (Fig. 2).

The advantage of having the peptide anchored to a solid support is that laborious purification steps are virtually eliminated. The method lends itself beautifully to automatic control, and machines suitably programmed to add reagents and wash the product at approximate times have been developed. At present, the chain can be extended by about six amino acid units a day. So, what

normally takes 3 to 4 years to synthesise a peptide of particular sequence can be done in three months in good yield.

In U.S.A., a 'do-it-yourself' peptide kit containing 100gm of chloromethylated polystyrene and 10gm each of various protected amino acids is available to high school students to prepare a polypeptide of their desired sequence.

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## Is chlorophyll-a a crystal?

THE existence of all living organisms is based primarily upon the ability of the green-photosynthesizing plant to utilize the energy of light to produce carbohydrate, an organic material. In the 4th century B.C., Aristotle mentioned that there was a relationship between sunlight and the development of green colour in plants. This is the first mention of the possibility that light may be a factor in plant growth. Ingen-Housz recognized the importance of light and chlorophyll in photosynthesis. In the process of

photosynthesis, the energy of sunlight is converted into and stored as chemical energy locked in the bonds of organic compounds through photochemical - electron transfer process. Modern literature suggests that the chain of chemical reactions in a photosynthetic cycle is triggered off by some specially deployed chlorophyll-a molecules through transfer of optical energy into electrochemical form.

Today the whole world is suffering from energy crisis. The greatest energy source is

the sun, which pours onto the earth 100,000 times as much energy as the world's present electric power capacity. To convert this abundantly available solar radiation into electricity we require a cheap solar cell. In solar cell photovoltage is generated as a result of the absorption of light in the vicinity of a potential barrier, caused by the contact between a metal and a semiconductor. For the efficient conversion of solar energy, theoretically, the semiconductor material should have a band gap, which is small enough to utilize most of the incident sun's spectra, but at the same time, large enough to minimise the magnitude of the reverse current. Studies of Terenin (1959),

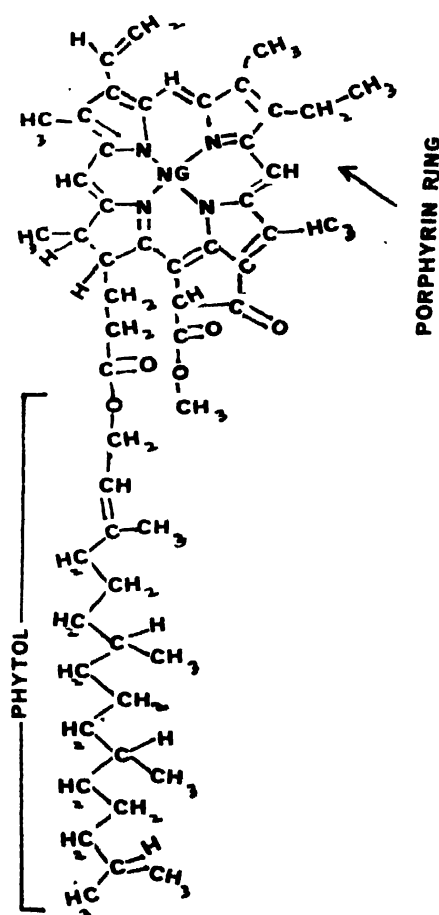


Fig. 1

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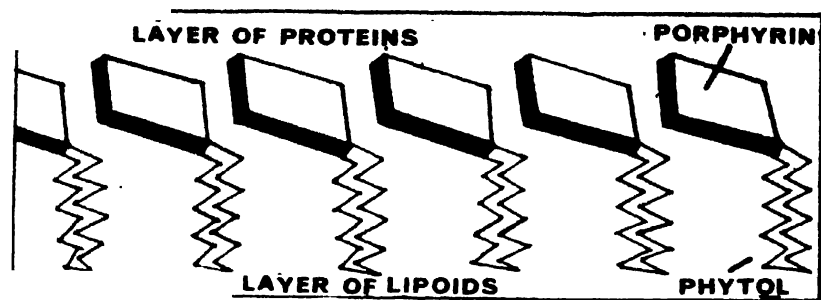


Fig. 2

G.A. Corker (1978) and a group of Japanese workers (1977) have strongly suggested that chlorophyll-a layers have insulating properties, indicating that it has a large band gap. Since chlorophyll-a, during photosynthesis, converts solar radiation into electrochemical energy, it cannot be just an ordinary insulator. It must be having some allowed states within its large band gap, so that it can behave as a semiconductor. A review of relevant literature shows that chlorophyll-a has crystalline properties with some inherent defects and, further, that chlorophyll-a has a large number of allowed states within its large band gap. These allowed states might help in effective utilisation and conversion of a significant part of the incident sun's spectra, if chlorophyll-a is used as a semiconductor in a metal-semiconductor heterojunction solar cell. So our first aim is to prove that chlorophyll-a is a crystal.

The structure of chlorophyll-a molecule contains two main portions (Fig. 1), a porphyrine ring, which is hydrophilic and a phytol chain, which is hydrophobic in character. Because of their differences towards affinity to water, they are arranged layerwise or in lamellar form inside a leaf, as shown in Fig. 2.

W. Arnold, while explaining the delayed fluorescence phenomenon in photosynthesis, considered chlorophyll-a as pseudocrystalline, in which electrons liberated by light absorption can get stuck in traps or irre-

gularities of the lattice of the pseudocrystal, surrounded by closely packed pigment molecules, to be released at some later time.

Substances that behave mechanically as liquids, yet exhibit many of the optical properties of crystals are known as liquid crystals. There is one important group of liquid crystals which are formed by the influence of solvents. These are known as lyotropic liquid crystals. The nature of molecular packing in lyotropic liquid crystals gives rise to a hydrophilic polar group, attached to a long hydrophobic hydrocarbon chain. One common example of such a crystal is soap water solution. As the water content is increased gradually, we get the neat or lamellar, viscous, isotropic and middle phases, respectively. In the neat or lamellar phase, the hydrophilic groups are arranged in layers with their heads arranged on flat surfaces and water is sandwiched between the flat surfaces. The hydrocarbon chain has a more or less disordered configu-

ration. Thus a lyotropic liquid crystal, in its lamellar or neat phase, exactly resembles the structure of chlorophyll-a molecules present inside a plant leaf. Like other liquid crystals chlorophyll-a in solution has been found to exhibit optical rotation.

The position of the absorption peak of a liquid crystal depends very much upon its chemical environment, mechanical stress exerted on it, its temperature, etc. The addition of extremely small amounts of certain chemical vapours can change the basic molecular structure of the liquid crystals and, thereby, affect their reflecting properties. It was found by E.E. Jacob, that the wavelength of the absorption peak of chlorophyll-a monolayer depends on the substrate on which it is placed. The red absorption peak of chlorophyll-a monolayer shifts from  $670 \mu$  to  $735 \mu$  due to the presence of  $\text{Ca}^{++}$  in water on which the monolayer is formed. Jacob further found that the red absorption peak of the colloidal suspensions of ethyl chlorophyllide shifts by an order of  $80 \mu$  towards longer wavelength.

To conclude, we say that chlorophyll-a is a lyotropic liquid crystal in its lamellar or neat phase.

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## Is chromosome number a stable and constant character ?

EVERY organism, whether plant or animal, in its cell(s) carries a fixed number of chromosomes and this remains constant from genera-

tion to generation. Thus, man has 46, maize 20, mouse 40, onion 16.

In most of the higher organisms (that are diploid) the chromosomes

are in pairs, one set being contributed by a female parent (mother) and another set by a male parent (father) at the time of fertilization. Subsequent changes in the chromosome number in the various tissues and organs of an individual during growth, maturation and senescence are not uncommon. However, through germ lines a constant chromosome number is maintained in any population and is thus a characteristic feature. Variation in the chromosome number of individuals in a population is not infrequent and is caused mainly due to aneusomy (a few chromosomes more or less than the diploid set, i.e.,  $2n+1$ ,  $2n+2$  or  $2n-1$ ,  $2n-2$ , etc.) and polyploidy (exact multiples of a set,  $2n$ ,  $3n$ ,  $4n$ , etc.) Hybridity, apomixis and the presence of B-chromosomes (accessory or 'second rate' chromosomes) may also lead to a change in the chromosome number, though rarely. These variants in a species population are described as cytotypes. Barring the situations mentioned above, chromosome number is a fairly constant character and is used in taxonomy (science of classification) by botanists and zoologists, alike.

Walter H. Lewis (Department of Biology, Washington University, U.S.A.) and his associates, R. L. Oliver and Y. Suda, report an extreme instability of chromosome number in *Claytonia virginica*, a plant belonging to the family *Portulacaceae* (*American Journal of Botany*, 49: 918-928, 1962; *Botanical Review*, 33: 105-115, 1967; *Annals of Missouri Botanical Garden*, 54: 153-171, 1967; and *Taxon*, 19: 180-182, 1970). *C. virginica* has two morphological races and about fifty chromosomal cytotypes!

Walter Lewis and his team studied a population of *C. virginica* growing near Carthage in Texas, an area of about 20 square meters with a gradual rise of about two meters near about the middle.

Plants of *C. virginica* are perennial having an underground corm that produces one to several flowering shoots over a period. Plants grow largely during warm periods. Plants at the top of the knoll flower first (late February) and flowering gradually continues down the slopes completing by March or early April every year. Chromosome numbers of these plants were studied through meiosis over a period of four years; 1961, 1967, 1968, and 1969. During 1961, 1968 and 1969, chromosome number in majority of the plants was  $2n=28$  or 29 ( $2n$  or  $2n+1$ , diploid chromosomal constitution in any organism is expressed as  $2n$ , meaning two sets). In 1967, there was a tremendous *chromosomal drift*, with over two-thirds of the plants showing less than  $2n=28$  of which 42% had only  $2n=24$ . That year, the plants during their six months of critical growth period faced a major climatic variation viz., the average rainfall was less than one-half of the usual precipitation (40 cm instead of 80cm-100 cm). Drought conditions, in other words, dramatically affected the chromosome number!

In 1969, three samples from this population were studied and it was found that plants with  $2n=28$  or 29 decreased from 58% to only 36%, while plants with number above  $2n=29$  increased from 31.5% to 56%. It was noted that early maturing plants at the top of the mound were mostly  $2n=28$  or 29 (the common number for the population) but the chromosome number increased as the season and flowering progressed down the slopes. Chromosome number, in other words, increased as one moved down the knoll! Among the samples showing more than 29 chromosomes, earliest flowering plants on the slope showed  $2n=30$ , to 36, while the latest

flowering plants nearer the base showed  $2n=30$  to 58. Seasonal ageing thus manifested greater variation in chromosome number. The 1969 population also showed increased meiotic abnormalities (mostly formation of univalents) from 6% at the beginning of flowering season to 26% late in the season.

Fascinated by this extreme instability in the chromosome number, Walter Lewis and his team moved some of these plants to green house for further study only to record still more exciting anomalies in chromosome number. Parts of the same plant above and below the ground showed different chromosome number! Among thirteen plants analysed by them in this way, five had the same chromosomal number in the tissues below and above ground, viz.,  $2n=14$ , 27, 28 (two plants) and 35. The remaining eight had  $2n=28$  in the roots uniformly but the aerial parts contained  $2n=29$  (two plants),  $2n=30$  (two plants),  $2n=31$  (three plants), while the eighth plant was a mixture; two racemes showed two numbers,  $2n=31$  and 33. This phenomenal disparity in the chromosomal number between root and shoot tissues of the same plant, according to Walter Lewis, is due to the direct or indirect effect of environmental factors, perhaps temperature. Underground parts show less variability because they are protected by earth.

Thus, chromosome number in *C. virginica* varies—(1) in the aerial organs and the roots of the same plant, (2) certain chromosome number is seen at one topography, yet others at another topography, (3) low chromosome number in individuals flowering during early part of the season and more in those that flower late, and (4) marked variation in the chromosomal number from one season to another. Having expressed such a tremendous instability of chromosome number, Walter Lewis is of the opinion that a



thorough screening of species population is essential before the characteristic chromosome number of a taxon is clear, and he does not support the dogma, 'one chromosome number-one taxon.'

The chromosome complexity outlined in *C. virginica* is unique and challenges the intellectual curiosity of scientists. Students of cytology usually avoid repetitive studies on chromosome number and behaviour, do not screen large number of plants, hesitate to analyse species populations and through various seasons (especially abnormal seasons), and more so do not consider populations growing under varied climates and ecological habitats. One is bound to record at least some degree of chromosomal variation if all these concepts are introduced under cyto-

logical studies of any group, plant or animal.

Ben W. Smith (Department of Genetics, North Carolina State University, U.S.A.) while commenting on the extreme chromosome-number flexibility in *C. virginica*, stresses on further study necessary on this group explaining the how and why of this chromosomal plasticity. "Claytonia material is extremely interesting," he adds, "but its extreme chromosomal instability need not undermine our confidence in the validity of the more frequently observed chromosome relationships."

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eroded stump, part of the tree is still alive. The growing tissue leading from partly bare roots to its thin crown is protected by a narrow strip of bark. An even older Bristlecone pine, growing in Nevada, was cut down in 1964. At that time it was at least 4900 years old. In addition, dead Bristlecone logs and stumps have been found that were living over 8000 years ago.

#### How the age is determined

How do we know that the Bristlecones are thousands of years old? The answer is quite simple. Every year most trees add a growing ring of new wood, called annual rings (Fig. 1). By counting these rings, the tree's age can be easily determined. Under favourable conditions, trees grow very rapidly, leaving easily recognisable annual rings. But Bristlecone pines grow in arid, hostile environments where growth is generally slow. In fact, these plants may grow so slowly that the annual rings may be only a few thousandths of a

## World's oldest living tree

**B**RISTLECONE pine, *Pinus aristata*, near timber line in the white mountains of California, U.S.A., attains spectacular age. Nearly 20 trees of this species are known to be older than 4000 years and to have been already more than 100 years old when the Great Pyramid was built in Egypt.

The current champion in this category is a 4600 years old tree called "Methuselah". It is the oldest known living thing on this earth. Though its trunk is now little more than an

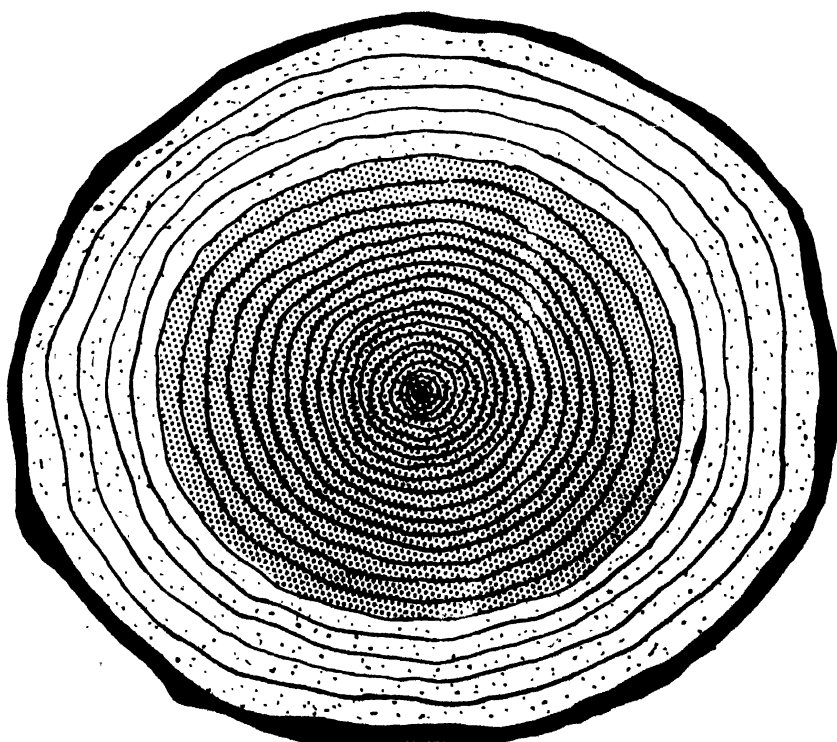


Fig. 1. Diagrammatic representation of a transverse section of a tree trunk, showing annual rings. The light coloured broad zones are of early (spring) wood and narrow dark coloured zones are late (autumn) wood. The early and late woods thus produced during the single growth season constitute a growth or annual ring.



Fig. 2. The oldest living tree of Bristlecone pine, *Pinus aristata* (Courtesy : *Living Plants of the World*)

cm thick requiring a microscope to be clearly seen.

#### Matching trees: cross-dating

Tree-ring chronologies are not limited by the age of the oldest tree. By matching the inner tree-ring of an old living tree with those in dead stumps and logs, scientists have built up an impressive sequence of Bristlecone tree rings extending over 8200

years into the past. Dendrochronologists (scientists who measure time by counting growth rings) have found that tree ring chronologies extending back hundreds or thousands of years are very useful in historical and archaeological studies. For example, when an archaeologist finds a wooden beam that was used in an ancient building, he can often date the dwelling by matching the pattern of tree-rings in the beam with a dendrochronologist for that area.

Tree-rings also provide a valuable source of information about localized weather and climate patterns prior to man's records. The date can be found by counting the tree rings and the climate is determined by studying the size, density and other characteristics of those rings. Obviously, when the rings are too small, we would expect that their growth was limited by some climatic factors, most possibly rainfall. From studying the annual rings, we can say in which years there was drought or when the tree was nourished with abundant water. Years of joy and sorrow are revealed by the structure and size of these rings. The tree serves as a silent chronicler of weather. It serves man both in life and death.

#### Carbon 14

What have Bristlecone pines to do with carbon 14? All living things including Bristlecones contain a small amount of radioactive element carbon 14. When an organism dies, carbon 14 begins to decay at a known rate. It has a half-life of  $5568 \pm 30$  years, which means that the quantity present in any particular plant material is reduced to half in that number of years. At the time of the death of the plant the acquisition of the radioactive carbon ceases; thus with a given sample of ancient wood or other plant materials the amount of carbon 14 remaining can be determined and its age calculated. But according to some research workers, carbon dating in case of Bristlecone pine may not be accurate, because it dates creatures long before 6000 years ago. However, the Bristlecone studies have shown that radiocarbon dating is generally accurate over the past 3000 years.

Outliving even the giant Sequoias by nearly 2000 years, the Bristlecone pine is proving to be a valuable

material for collecting past information. Perhaps it is only fitting that the world's oldest living thing should also provide the key to so many

fascinating riddles of the past.

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## The Assam rabbit

**H**ARES and rabbits are placed under the mammalian order Lagomorpha. Squirrels, guinea-pigs, rats and beaver rats are grouped under the order Rodentia. Formerly, hares and rabbits were included under rodents as a sub-division, the Duplicita. It is now generally agreed that the two groups of animals have practically nothing in common except superficial resemblance. The points of difference between the two groups are quite well-marked to be missed (Table I).

Hares are characterized by long hind legs which give them great leaping ability and high speed. They have long ears. They primarily live in the open country. Hares escape their enemies by speed and by dodging.

Rabbits on the other hand, have comparatively shorter hind legs, shorter ears. They live in wooded, bushy or mixed areas. Rabbits escape their enemies by dodging or by remaining frozen in concealment.

Interestingly, although several

species of hares are found in the Indian region, there are no true rabbits in India. The Assam Rabbit or Hispid Hare, *Caprolagus hispidus* (Pearson) is a closely related form and hence bears the name of both 'rabbit' and 'hare'.

The Hispid hare or harsh furred hare is extremely rare. It was first described by Pearson in 1939. Although sporadic reports of its occurrence in the grass jungles of the Terai and the Duars of the Himalayan foothills are available, very little is known about their habits. In 1951, it was reported from Kheri on the Uttar Pradesh-Nepal border (Prater, 1965). In 1956, a German zoological team collected one in the Goalpara Division of Assam. The last record was in 1971 when an adult male was caught in the thatchlands between Rajagarh Forest Reserve and the Attareekhat Tea Estate, in the Mangaldai Sub-division of Durrang District, Assam:

Size—Male: Nose tip to bass of

Table 1

Distinguishing character	Hares and Rabbits (Lagomorpha)	Squirrels, Guinea-pig, Rats, Beaver rats (Rodentia)
Teeth	<p>Possess two pairs of upper incisor teeth, the second pair very small and a single pair of lowers.</p> <p>The incisors (especially the lowers) are relatively short, and do not form efficient chisels as in rodents, because the enamel surrounds the tooth, instead of being limited to the anterior face.</p> <p>Dental formula:  <math display="block">\text{I. } \frac{2}{8} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{3}{2} \text{ M. } \frac{3}{3} \text{ Total : 28}</math></p>	<p>Possess one pair of long chisel-like incisors which project at the front of the mouth. They bear enamel only on the front surface.</p> <p>Dental formula:            Squirrel I. <math>\frac{1}{1} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{2}{1} \text{ M. } \frac{3}{3} \text{ Total : 22}</math>            Guinea-pig I <math>\frac{1}{1} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{1}{1} \text{ M. } \frac{3}{3} \text{ Total : 20}</math>            Rat I. <math>\frac{1}{1} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{0}{0} \text{ M. } \frac{3}{3} \text{ Total: 16}</math>            Beaver rat (<i>Bydromys</i>): I. <math>\frac{1}{1} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{0}{0} \text{ M. } \frac{2}{2} \text{ Total:12}</math>            (<i>Mayermys</i>): I. <math>\frac{1}{1} \text{ C. } \frac{0}{0} \text{ Pm. } \frac{0}{0} \text{ M. } \frac{1}{2} \text{ Total: 10}</math></p>
Scrotum	Lies in front of the penis which has no bone.	Lies behind the penis which has a bone.
Refection	Soft faecal pellets are produced by the caecum which is egested in the early hours of daylight. They are eaten by hares and rabbits directly from the anus and are swallowed whole. They are retained in the stomach for some hours. Hard faecal pellets are produced by the colon which are not eaten. Refection ensures best use of plant food.	Refection does not occur.
Birth	A birth well furred and have open eyes; are born in "forms" in grass.	At birth nearly naked and blind; are born in burrows.

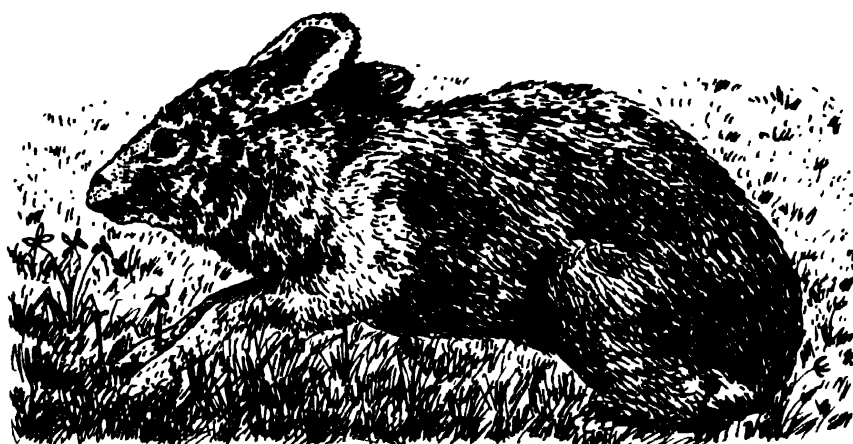


Fig. 1. Hispid hare of Assam

tail 46 cm; shoulder height 18 cm;  
tail 13 mm; ear 6 cm.

#### Distinctive characters

The colour of the animal is dark-brown and blackish with numerous scattered whitish bristle-like hairs. The most distinguishing characteristic of the Hispid hare is the small size of its ears and tail.

#### Distribution and habits

It is found in grassy or scrub-forest areas along the foothills of

the Himalayas in Uttar Pradesh, Bihar, West Bengal and Assam.

The Hispid hare is reported to burrow like rabbits. In captivity, it subsists on dub grass, *Cynodon dactylon*.

In the *Wild Life (Protection) Act, 1972* the Hispid hare is listed under Schedule I, which gives absolute protection to the animal by forbidding its hunting, trapping, possession and sale.

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## Muscular contraction

**M**USCLES are unique among body tissues in demonstrating to the eye even of the lay person the power to convert chemical energy into kinetic energy. These are the prime movers of the body. They help us in movement, grasping, striking and lifting. The voluntary muscles of the body attached to the bone are known as skeletal muscles. These function generally under conscious control. The skeletal muscles have cross striations or bands and thus

are also known as striated muscles.

#### Chemical composition

Chemically the striated muscle consists of :—

	%
Water	.. 75
Proteins (globulins)	.. 20
Carbohydrates	.. 1
Fats, enzymes, inorganic salts (sodium, potassium, magnesium, calcium)	.. 4

Water molecules constitute the medium through which energy transmitting molecules pass. It also serves as a liquid medium in which the contractile molecules of the myofibrils (muscle fibrils) move. These fibrils contain atleast 4 globulins—actin, myosin, tropomyosin, and troponin. These proteins are absent in non-muscular tissue.

Normally a muscle contracts in response to a nerve impulse. In addition to this, it also contracts when a direct electrical, mechanical, chemical and thermal stimulation is applied.

#### Electrical properties

A chemical transmitter (acetylcholine) is released at the motoneurone (nerve going from centre to the muscle) terminal. This substance then enters and depolarizes (stimulates) the end plate region of the muscle fibre membrane. If this depolarization is enough, a local circuit current depolarizes the adjacent inactive fibre membrane. An electrical depolarization (excitation) wave is then initiated and it passes along the muscle fibre membrane. This is carried inwardly to the myofibrils within and finally the muscle contracts. The velocity of this current (action current) in mammalian skeletal muscles is nearly, 5 m/sec. Once an action current is initiated, an inward ion current due to sodium influx (inflow) occurs in the local area of depolarization. Along with the inward current there is an outward current in the immediately adjacent area. This outward current tends to produce depolarization. Depolarization in one area predisposes adjacent areas to depolarization, and thus the wave is propagated, usually in both the directions from the point of initiation. The repolarization phase is partly due to increased permeability to potassium ion. The outward flow of potassium tends to restore the electronegativity on the inside of the membrane at a rate pro-

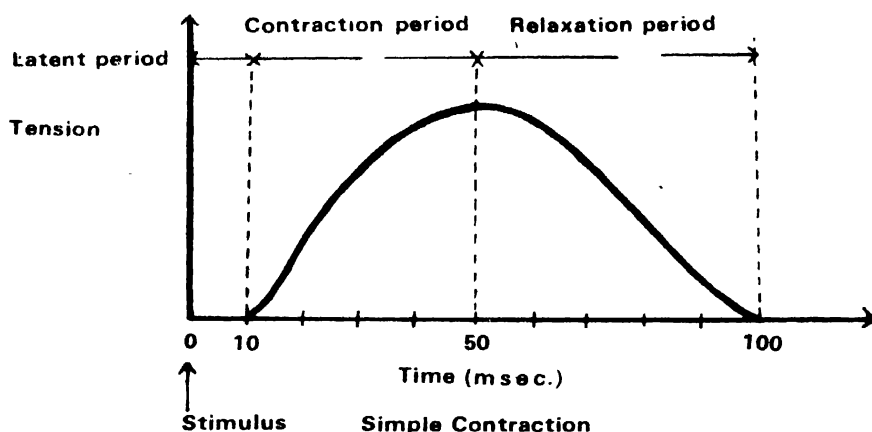


Fig. 1

portional to internal potassium concentration. The chloride ion influx delays the repolarization process. The rate of mechanical contractile response depends upon the metabolic rate of the muscle, temperature and the strength of the stimulus.

#### Types of contraction

The striated muscle in the body at rest is usually under slight tension. The maximal contraction force is obtained when the muscle length equals the normal resting length. Under normal circumstances, muscle is stimulated by volleys of nerve impulses rather than a single impulse. Therefore, a simple twitch (contraction) does not occur naturally. A simple twitch consists of three phases, the latent period (time taken by a muscle to initiate the contraction), the contraction period (time of contraction), and the period of relaxation (time of relaxation).

The latent period occurs between the onset of the stimulus and the onset of the observable muscle contraction. In this interval the action current develops and excitation takes place. Presumably, calcium ions are released from the depots and are diffused into the interfilament regions. The contraction period begins as soon as the muscle develops enough tension to overcome its own inertia to produce detectable shortening. The relaxation

period covers up all activity after the contraction period of the simple twitch. In this interval the muscle returns to its resting length and all the chemical activity concerned with restoring the muscle to resting equilibrium conditions takes place. Relaxation can occur only if the sarcomeric (muscle) filaments are allowed to disengage. This disengagement parallels the dissociation of actin and myosin. It will take place if calcium ion be removed from the myofibrils.

The other important phase in muscle contraction is the refractory period. This is the interval following an initial stimulus during which a second stimulus cannot evoke the contraction of the muscle. In this the muscle membrane is already depolarized. During the early part of the refractory period, the absolute refractory period, a strong second stimulus will not produce a muscle response. During the last part of the refractory period, termed the relative refractory period, a strong second stimulus may produce a contraction. In this stage the membrane has again become irritable due to partial repolarization, when a single muscle fibre is stimulated in the normal manner, it either responds to the maximum amount that it is capable of at the time or fails to respond at all. The factors influencing it are tem-

perature, pH, nature and concentration of catabolites present, and the availability of ATP (adenosine triphosphate). This is *All-Or Nothing Law*: it states that when an excitable membrane is stimulated (depolarized), it will either fail to react or it will react maximally. The initiation of a propagated response depends upon a specific membrane depolarization threshold being attained by the stimulation process.

Muscle tension varies with the frequency of stimulation. During voluntary muscle activity motoneurons discharge at rates increasing from approximately 5-50 impulses per second as the effort achieved increases from minimum to maximum. A synchronous activity results because muscle fibres are recruited at different times and contract at different rates. At the lower rates of muscle stimulation, the individual muscle fibres perform a series of contractions. As the frequency of motoneuron discharge approaches the upper end of the range, the individual contractions begin to fuse until at a critical point called the fusion frequency, the state of tetanus (continuous contraction) is attained. During complete tetanus the muscle is in a continual state of contraction with no muscular relaxation taking place between successive nerve impulses. Muscle force is maximum at this rate, and more rapid motoneuron discharge, even if it were possible, would not yield greater force. In the normal resting state, skeletal muscle rarely relaxes completely. Instead, the fibres exhibit tonus, a persistent state of partially sustained contractions. Tonus is characterised by a low degree of activity, low enough that oxygen consumption and the chemical processes of recovery are not taxed to the point where muscle fatigue develops. Tonus is maintained by centrally originating motor nerve impulses. There are two types of contractions.

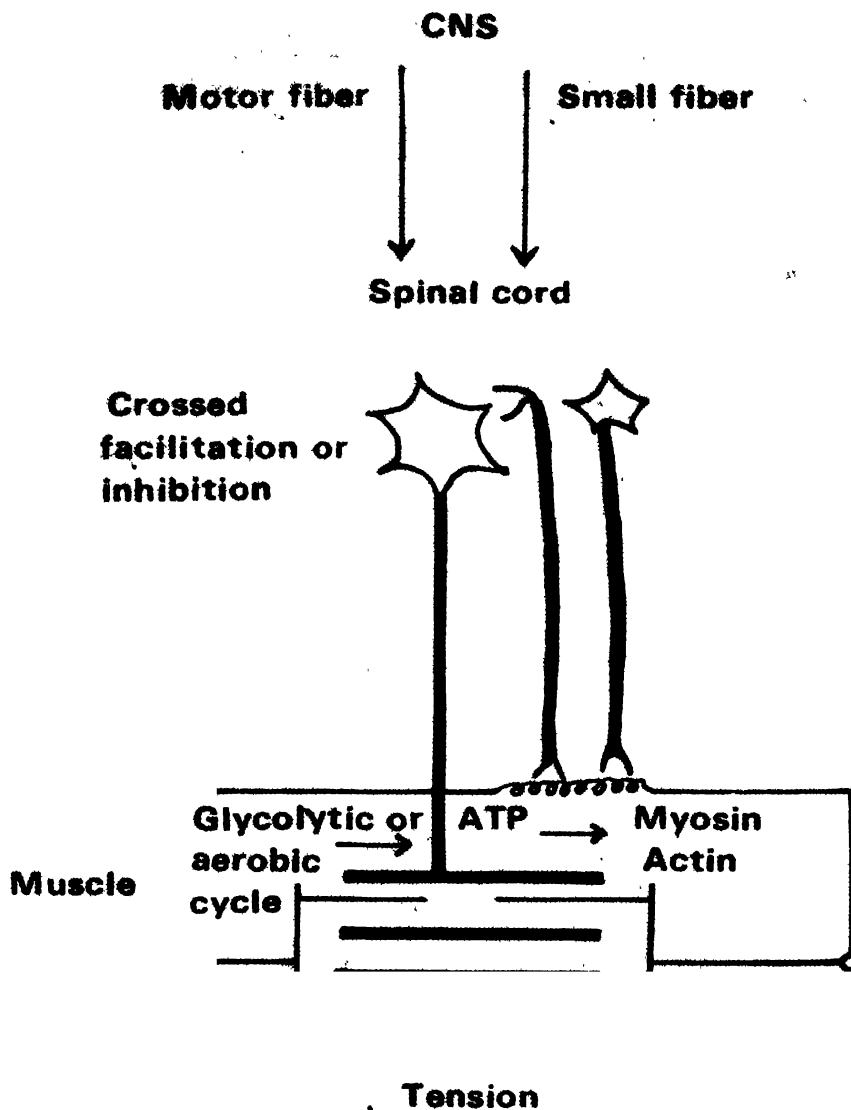


Fig. 2. Central nervous system (CNS) and muscle contraction

1. An isotonic muscle contraction is one in which the muscle changes in length under constant tension. Here the muscle is firmly attached at one end but the other end is free to move. In nature, any muscle contraction during which mechanical work results, such as running or lifting, is isotonic. In this case the muscle contracts and does the work. During contraction muscle becomes thicker, shorter and undergoes a slight reduction in volume due to mechanical compression. During relaxa-

tion the volume change reverses. When the muscle is fatigued latent period, relaxation period increase and height of contraction is decreased. If the load (weight) is increased, height of contraction is decreased, periods of contraction and relaxation become altered in form. The amount of work done at each contraction may be calculated by multiplying the weight lifted (force) by the distance through which it was lifted.

An increase of temperature shortens the latent and contraction pe-

riods. The gradient of contraction is increased and the height is usually decreased. Relaxation is little detected either as to duration or gradient. A decrease of the temperature has the opposite effect on the latent and contraction periods and prolongs the relaxation period. In intact animals the muscle contractions are of isotonic type.

2. An isometric contraction is one in which the muscle contracts without length. It occurs in nature when one holds an object stationary or when muscle contracts to maintain posture. Here muscle activity is directed towards preventing motion against an opposing force. During a true isometric contraction chemical energy is transformed solely to heat energy with no external work being performed. If the load or opposing force exceeds that developed by the isometrically contracting muscle, then the muscle is forced to lengthen and negative work is done. In intact (living) animals isometric contractions can occur when muscular effort is exerted against a fixed or a heavy object or when skeletal muscle is in a state of tonus (partial contraction).

#### Changes during contraction

During contraction muscle produces heat which is of three types, resting, initial and recovery. Resting muscle produces measurable heat. It depends primarily upon aerobic exothermic chemical reactions (requiring oxygen and releasing heat). When muscle begins to contract, production of heat is increased as compared to the initial heat. Initial heat can be classified into several consecutive processes. The first of these is the heat of activation or maintenance. This phase of heat production commences in the interval between excitation and the beginning of actual contraction, and continues as long as the muscle remains activated. The next stage, heat of shortening, is initiated when the sac-

comes decrease in length. If a muscle contracts isometrically, there is no heat of shortening. When a muscle is stretched that is when a muscle performs the work, heat flows from the environment into the muscle. Heat of relaxation is a physical process resulting from the potential energy liberated from a tense and shortened muscle as it passively lengthens. The heat of relaxation is directly proportional to the amount of work done by the muscle during contraction. For a period as long as 30 minutes immediately following relaxation, many chemical processes operate to restore the muscle to resting equilibrium state. The amount of heat freed during recovery approaches that liberated during the actual muscle contraction.

Adenosine triphosphate (ATP) is the primary contributor of energy for contraction, all of which is bound to myosin in the muscle. ATP breaks down to release one molecule of ADP (adenosine diphosphate), phosphate and energy. Generally in contracting muscle, the ADP does not breakdown further to release more energy but eventually is recycled back to form ATP. The level of ATP in contracting muscle rarely falls to low levels. It is supposed that more ATP is created from ADP by rapid transphosphorylation of creatine phosphate. These reactions are entirely anaerobic (do not require oxygen). A byproduct is lactic acid. A portion of lactic acid is carried from the muscle to the liver. There it is reconverted to glucose. Most of the lactic acid is not removed but accumulates in the muscle and lowers the pH. Thus, it produces muscle fatigue. During the period following exercise, oxygen is again made available to muscle at rates exceeding the instantaneous metabolic demands. At this time oxygen is used mainly to abolish the deficit incurred during exercise. Here, it is utilised in the oxidation of lactic acid. Oxygen debt refers to the disparity between the

total oxygen need at the end of the period of muscle activity and that which was actually delivered. This debt is abolished in the recovery period following cessation of contraction.

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## Metabolic changes in starvation

**H**UMAN body is like an intricate machine which needs fuel to keep it running. This is normally provided by the macronutrients in food—carbohydrates, fats and proteins. A second group of food constituents, the micronutrients, including the vitamins and minerals is required for the utilization of the macronutrients in energy-generation through oxidative metabolism, as well as for numerous other vital processes occurring in the organism. Finally there is water, a considerable amount of which is lost daily through various excretions (including urine and sweat), and which must therefore be replenished.

The voluntary or involuntary denial of food, as occurs during fasting

**Table 1. Tissue fuel need and fuel content of an average 70 kg man on an average diet**

Tissue	Fuel	Fuel consumption gm/day	Energy reserved K. cal.	Average diet intake
Brain	Glucose	120	480	Protein 70 g-280 g
Liver	Amino acids	70	280	Carbohydrate 220 g-880 g
Muscle	Glucose, Fat	60 & 60	780	Fat 60 g-540 g
				160
Anaerobic tissue, viz., R.B.C. Renal Medulla Testis	Glucose	40	160	
			1700	

**Table 2. Energy reserves of a 70 kg man**

Fuel	Tissue	Fuel in g	Reserved energy (K. cal.)
Triglycerides (Fat)	Adipose tissue	15,000	135,000
Glycogen	Liver	70	280
	Muscle	120	480
Glucose	Blood plasma and other body fluids	20	80
Protein	Muscle	6,000	24,000

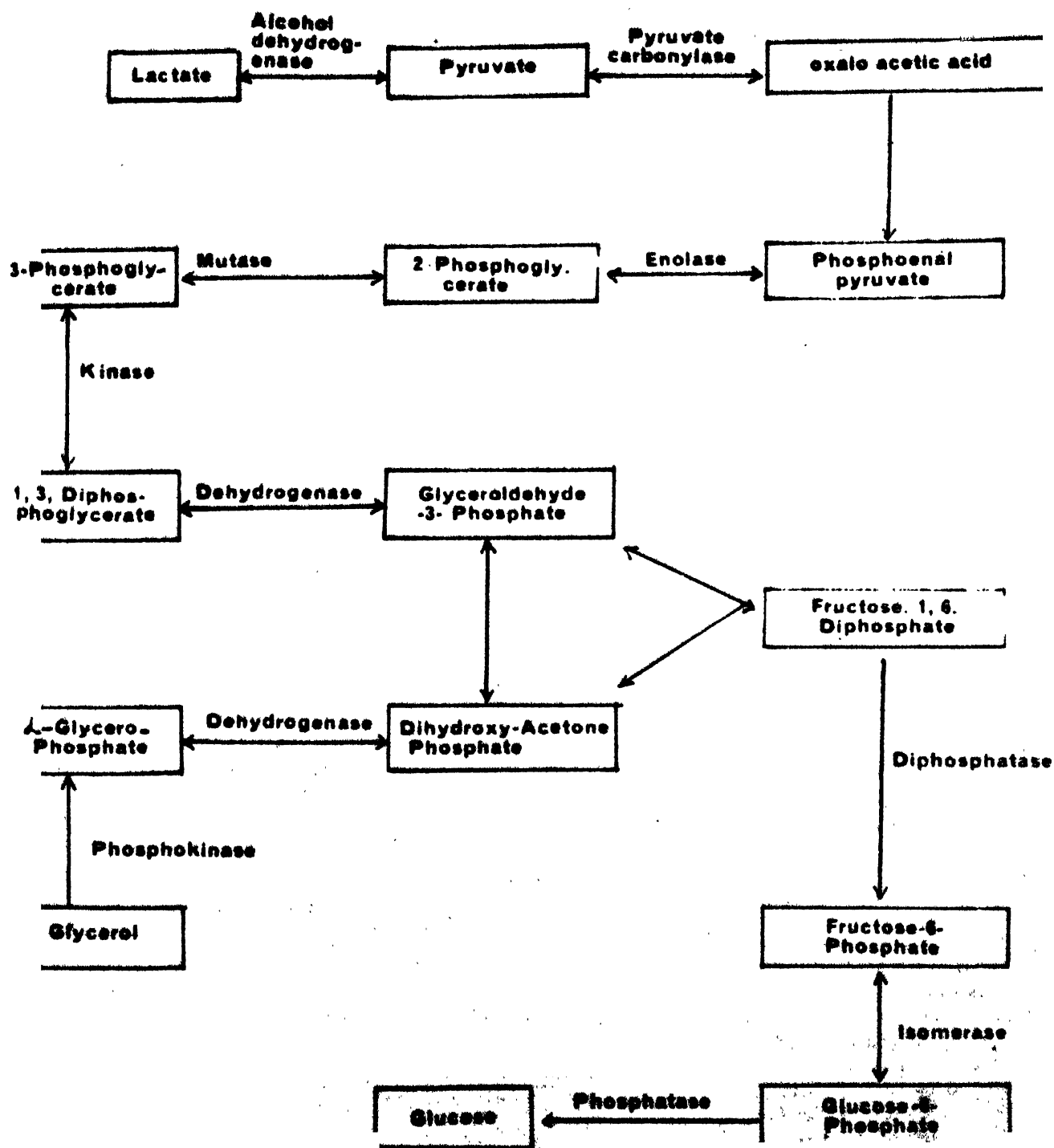


Fig. 1. Conversion of lactate and glycerol to glucose

for limited periods without food. We shall consider the mechanism of survival later, but it is worth noting

here that different species of animals and plants have different capacities for doing so. Animals like camels,

and turtles are, however, exceptions. Another prime example of starvation in nature is offered by the hibernating



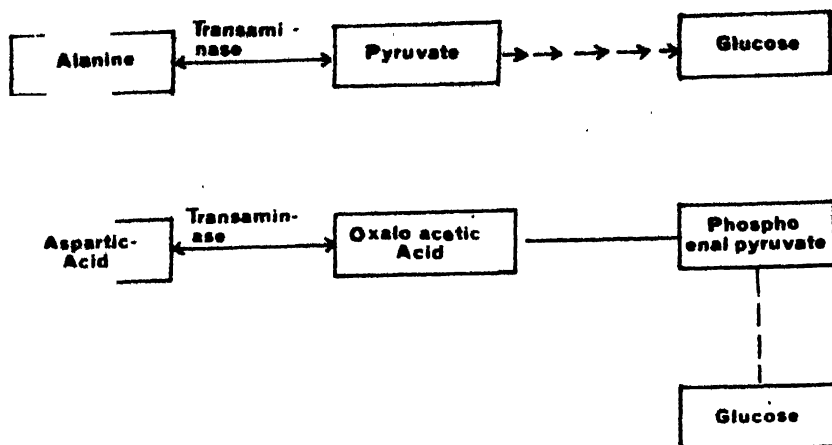


Fig. 2. Conversion of alanine, aspartic and glutamic acid to glucose

intake does not lead to a cut down of glucose requirement of the brain and the anaerobic tissues. Muscle glycogen is not depleted in early starvation, and the maximum effective glucose reserve is 90 gm (Table 2). With this glucose reserve a starving man can survive only for a limited period. So, during this period, glucose must be produced in the body from the non-carbohydrate sources.

### Carbohydrate metabolism

The important precursors of glucose are lactate, glycerol and glucogenic amino acids, particularly alanine. Pyruvate is formed from lactate and is converted into phosphoenolpyruvate, phosphoglycerate, glyceraldehyde 3-phosphate, fructose-6-phosphate, glucose-6-phosphate, and then into glucose with the help of several enzymes (Fig. 1). Glycerol, derived from the hydrolysis of body fat, also gives rise to glucose through the same pathway (Fig. 1). The glucogenic amino acids, derived from

animals which survive in winter for months without any nourishment

### What happens during starvation

During starvation, the body has to mobilize the inner resources, i.e., fuel reserved in the body. In 1966-69, G. F. Cahill of the Joslin Research Laboratory, Harvard Medical School and Diabetes Foundation, USA calculated the fuel balance sheet for man (Table 1). The total glucose need of an average man, about 220 gm per day, is satisfied by carbohydrate intake in diet. Muscle can utilize fats, therefore its glucose need is less. The minimum glucose need per day of an average man is 160 gm, but a reduced

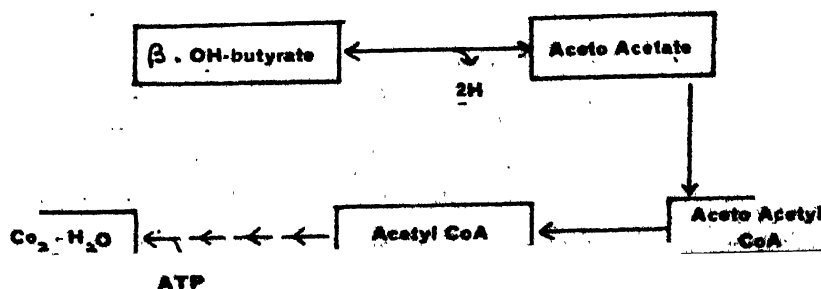
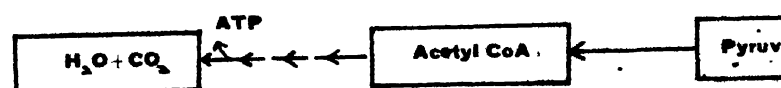
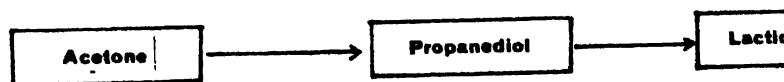


Fig. 3. Oxidation of ketone bodies during starvation

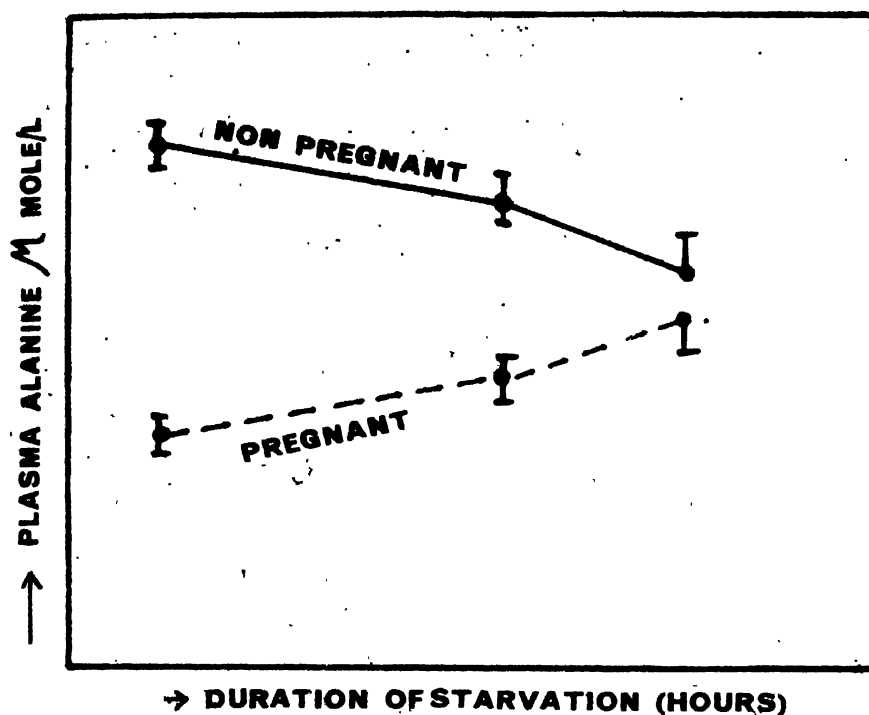


Fig. 4. Changes in plasma alanine during starvation

protein breakdown, also produce glucose through the glycogenic pathway (Fig. 2). Glucogenesis initially takes place only in the liver, but during prolonged fasting the kidney also starts to generate glucose (Table 3). The amount of glucose available to the brain is 60 gm and 35 gm in the early and late stages of starvation respectively. The glucose need of brain per day is 120 gm, thus glucose deficiency of the brain is 60 gm and 85 gm respectively under these conditions. It was found out that the brain contains an enzyme system for oxidising ketones arising from ketosis of body lipids (Fig. 3). After 5 to 6 weeks of starvation, 75% of the energy demand of the brain is met by ketones. Looking at the Table 3 we find that on the third day of fasting, the body makes 42 gm of glucose from protein. This is equivalent to about 75 gm of body protein.

Likewise, the total protein reserve in the body is about 6 kg. If the average consumption is 75 gm per day, the total reserved protein will

be exhausted within 80 days. Again, loss of 65% of the body protein can cause death. This danger is reduced by a cutdown of gluconeogenesis of amino acids, i.e., reduced breakdown of body protein which starts as soon as shifting of the brain from

glucose to ketones occurs (from about the third day of fasting). Glucose production from pyruvate, lactate and glycerol remains almost constant. As starvation continues, the conservation of body protein gradually gets prominence in metabolic changes. Only 16 gm of body protein is used per day after 5 or 6 weeks.

#### Protein metabolism

Protein breakdown is prominent during early stage of starvation. This results in elevation of amino acid levels in plasma and subsequent catabolism of amino acids in liver, accompanied by increased urinary nitrogen. This state discontinues after a few weeks (Fig. 4). Studies, in which exogenous alanine has been administered to fasted subjects, provide evidence of the importance of availability of this amino acid in the control of gluconeogenesis in starvation. Intravenous infusion of alanine after 46-weeks fast results in a prompt increase in blood glucose concentration. In contrast, replacement of carbohydrate by fat results in a specific fall in plasma alanine concentration. These dietary studies

Table 3. Glucose production in man during starvation

Precursors	Glucose production	
	Brief fasting 3-4 days	Prolonged fasting 5-6 weeks
Glycerol	19	19
Lactate and Pyruvate	39	39
Amino acids	41	16
Total glucose production by gluconeogenesis	99≈100 g	75≈75 g

Table 4. Hormonal changes during starvation

Blood constituent	Fasting days—3	Fasting days—7	Fasting onwards	Normal absorption value
Blood glucose mg%	60—70	60—70	60—70	100—120
Blood insulin $\mu$ M/ml.	8	8	8	15
Blood glucagon pg/ml.	144	115	115	73

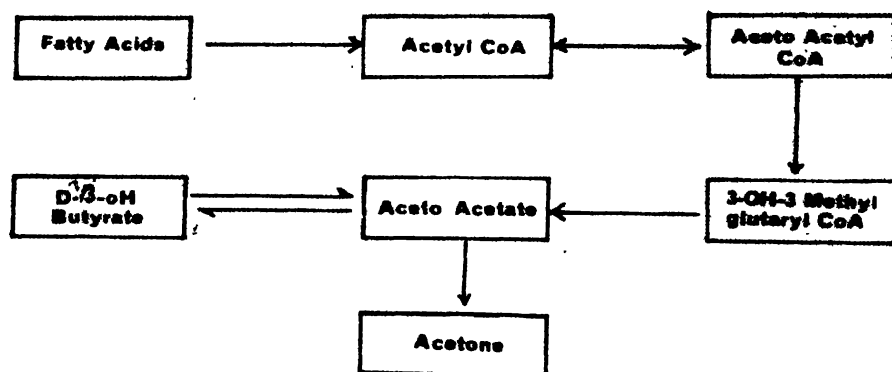


Fig. 5. Oxidation of fat and ketosis during starvation

indicate that plasma alanine levels are reduced in circumstances in which the need for gluconeogenesis is augmented. On the other hand, when an excess of dietary carbohydrate is available, even in the case of protein lack, alanine accumulates in blood, presumably as a consequence of decreased consumption for gluconeogenesis.

In the terminal stages of fasting, i.e., just before death, when all other energy sources (viz., carbohydrate and lipid) have been exhausted, protein and nucleic acid breakdown are once more accelerated. This is reflected in elevated plasma and urinary nitrogen levels, resulting in negative nitrogen balance.

#### Lipid metabolism

During fasting there is an extensive mobilization of body fat which is

hydrolysed to free fatty acids and glycerol. Glycerol is a glucogenic precursor. The liberated free fatty acids are used for energy (ATP) generation in heart, kidney and muscle. Besides these, ketone bodies are liberated in liver through ketosis and are used as fuel by peripheral tissues like brain and muscle during prolonged fasting (Fig. 5). Kidneys show enhanced reabsorption of plasma ketones during starvation to help conserve this important source of energy.

#### Hormonal changes

Many of the abnormalities associated with protein, carbohydrates

and lipid metabolism during starvation can be explained on the basis of changes in the hormonal levels in plasma (Table 4). The important event in early fasting is that insulin level is depleted and glucagon level goes up. The reduced insulin results in the release of amino acids from the muscles and enhances lipid mobilization from adipose tissue.

The metabolic response to starvation is triphasic. The changes in body fuel metabolism differ in early and late stages of starvation. The initial response is devoted to maintaining hepatic output of glucose by gluconeogenesis while the late response is directed at maintaining body protein reserves. Both the conservation of body protein and switching over of the brain and other tissues from glucose to ketones contribute to the survival; just before death the body protein reserves are exhausted as there is extensive protein breakdown to sustain the organism.

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## Food from inorganic compounds

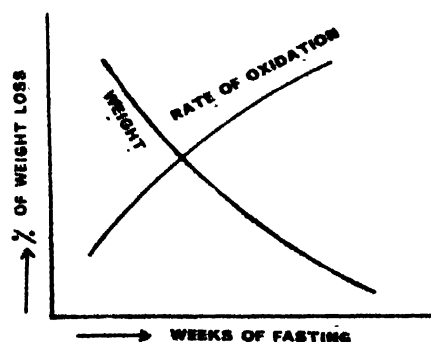


Fig. 6. Body weight changes and fat oxidation during starvation

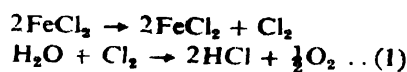
FOOD from inorganic compounds! It sounds incredible. But a recently developed process makes this possible. The process envisages the use of solar energy and inorganic compound for the production of bacterial biomass. This bacterial biomass can be suitably processed to produce food, which is rich in protein and other nutrients and fuel.

There are many advantages of this process. It has been theoretically

calculated that the yield of biomass from this process is about 10.5 to 17.5 per cent. The process utilises about 35 per cent of the incident solar energy. The process requires neither fertile soil nor abundant supply of water. So it can be conveniently employed in deserts and regions with infertile soil. An added advantage is that the process can be worked in a compact and automatic factory

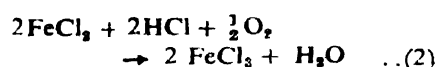
Another process to produce biomass using solar energy is photosynthesis. It requires fertile soil and abundant supply of sweet water. The yield of the biomass through this process is very low; the maximum yield is 4 percent. The conversion of solar energy by this process is also very low and ineffective, about 5 per cent to 6 per cent.

•Hilmut Tributsch of Laboratoire de Bellevue, Paris, France, has reported in a recent issue of *Nature* (18 October 1979) about the new process for the production of biomass. The new process is executed in two steps. In the first step, a suitable inorganic compound is produced through a thermochemical reaction which uses solar energy. In the second step, which is the important step, this inorganic compound is used as a source of energy for the growth of a suitable bacterium. One of the many bacteria which can produce biomass by this process is *Thiobacillus ferrooxidans*. In the first step, ferrous iron is produced. One of the ways in which ferrous iron may be produced is as follows :



These reactions are endothermic

in nature, in that energy is needed for the reaction to occur. This energy is supplied as solar energy. In the second step of the process, the bacteria is grown on the ferrous iron produced in reaction (1). The bacterium is autotrophic in nature. It requires  $\text{CO}_2$  for its growth, which it obtains from the atmosphere.  $\text{CO}_2$  is fixed by biochemical mechanisms. The bacterium requires an environment of a particular acidity and an optimum temperature of  $34^\circ\text{C}$  for its growth. The reaction which releases energy for the growth of bacterium in the second step is:



Theoretical calculations show that this process is economically feasible. The bacterial biomass that is produced is rich in protein; *T. Ferrooxidans* contains 44 per cent protein, 26 per cent lipids, 15 per cent carbohydrates, and at least two 'B' vitamins. It has no known negative physiological effects and can be manufactured in factories of moderate size.

The process, however, suffers from a disadvantage. The oxidation reaction of ferrous chloride

(Reaction 2) generates a small amount of energy. So a relatively large quantity of material ( $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ) would have to be circulated to obtain a small amount of energy. This difficulty can be removed by replacing the solar thermal reaction (Reaction 1) with solar powered electrochemical cells or photoelectrochemical cells. The cells may be so designed as to produce ferrous iron in the cathodic reaction and oxygen in the anodic reaction. In this case the bacteria can be grown in the same reactor in which their energy source is produced. It is estimated that the total efficiency then will be of the order of 6 per cent.

The new process for getting biomass from bacterial sources is based on established principles and does not involve expensive raw materials. The new process also breaks down some of the restricting environmental conditions imposed on the present process for producing biomass, which uses solar energy. If the new process is found economically feasible on a large-scale, then a larger area of the world will be available for production for food, fuel and material.

P. SUNDERARAJAN

#### Corrigenda

1. Refer *The story of II* (S.R., September 1979), on page 595, second column, in last line, please read  $(\frac{1}{2})^4$  as  $(\frac{2}{3})^4$ .
2. Refer *Vitamin D—a vitamin or hormone* (S.R., November 1979), on page 768, first column, in the 6th line from bottom, please read 300 mg—500 gm as 300 g—500 g. Same page, third column, in 18th and 19th lines, please read 25 hydro-vitamin  $\text{O}_2$  as 25 hydroxy vitamin  $\text{D}_3$ .

## IAEA Conference

**T**HE 23rd General Conference of the International Atomic Energy Agency was held in New Delhi from December 4 to 10, 1979. Delegates from 81 countries and representatives from a number of international agencies attended the conference, which was inaugurated by the Prime Minister. Dr. H. N. Sethna, Chairman of the Atomic Energy Commission, of India, was unanimously elected as the President of the the Conference.

In his address to the Conference, Dr. Sigvard Eklund, Director General of the Agency, pointed out the need for more nuclear energy in view of the growing world population and less likelihood of tapping new energy sources in the near future. He emphasised that nuclear hazards, though look enormous, are as dangerous as from any other source. Today, about 230 nuclear reactors are functioning all over the world totalling over 1800 years of reactor experience, but there has not been a single case of human death. Besides, radiations from nuclear reactors, he emphasised, form only 0.15 per cent of the total dose incident on man from various sources, natural as well as artificial.

The 110 member Agency is a body set up in 1957 to provide technical assistance in matters of nuclear knowhow for peaceful uses to its members. Knowhow is given for not

only building of nuclear reactors and their maintenance but also applications of nuclear radiations in agriculture, geology and other related sciences. In recent years, the issues of safeguards of nuclear power plants and the disposal of nuclear waste have come to the fore. It is also the function of the Agency to see that its member countries follow the safeguards for their nuclear reactors and to help them in disposing of the nuclear waste. Besides, it also keeps a count of the nuclear fuel it supplies to its members, so that the fuel is not used for making nuclear weapons. Enforcement of safeguards is done in accordance with the Nuclear Non-proliferation Treaty which came into force in March 1970. To date 111

countries have signed the Treaty which does not include India.

Delegates from the developing countries were of the view that technical assistance was being denied to them. They pointed out that the Agency was allotting more of its funds for maintenance of nuclear safeguards rather than the promotion of technical assistance, which is its primary role. During the Conference, attention was focussed on three or four main issues: how to increase the funds available for the technical assistance activities of the Agency; composition of the governing body of the Agency; issues related to supply assurances of nuclear fuel; and the Agency's budget for 1980.

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### Symposium

## **Vegetational wealth of India**

**A** six day botanical symposium on the vegetational wealth of Himalayas was held from Oct. 1 to 6, 1979 at Department of Botany, University of Garhwal, Srinagar (U.P.) It was sponsored by Indian National Science Academy, Uttar Pradesh Council of Science and Technology, Department of Science and Technology, Indian Council of Agricultural Research and the University of Garhwal. The symposium was inaugurated by Shri Sundar Lal Bahuguna, the famous forest conservator. More than 150 research papers were presented at the symposium for discussion and about 40 botanists participated in the symposium. The delegates were distinguished workers in different aspects of Himalayan botany. The most important topic of discussion was the forest conservation and preservation of rare Himalayan plants. The need of conservation of forest wealth was established. Ecological balance

in Himalayas was suggested not to be disturbed. Bahuguna, the Uttarakhand Chipko Andolan leader, stressed the importance of having no more roads in the hills. Such factors are responsible for serious hazards and he cited the example of recent land slide in district Chamoli of Garhwal, which is a result of ecological disturbance. He recommended some measures of forest conservation, namely, preservation of trees and plantations on bare areas. 'Chipko Andolan' was supported, and an appeal was made for stopping the commercial felling of trees. The other aspects of discussion were Himalayan flora with special reference to alpine flora, ecology and ecogeography, survey and mapping of Himalayan plants, the danger of vanishing species, the exploitation of rare medicinal plants, the morphological and evolutionary themes presented by Himalayan plants, adaptation of high altitude

plants, cytotaxonomic analysis and pathology of Himalayan plants.

There was also a discussion on the recommendation of plantation of certain useful trees such as *Eucalyptus* and fruit trees to check erosion of hills. It was recommended that conservation of Himalayan plants should be included in the syllabus

of Garhwal University. The symposium was also attended by geologists, geographers, economists and Sankrit mythologists.

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### Interview

## Dr. J. K. Ladha

WHAT should be done to improve the standard of research in India? The 1979 INSA Young Scientist Award winner, Dr. Jagdish Kumar Ladha, has some points to make. First of all, he says, students should be tested for aptitude in research because most of them consider fellowships as 'unemployment doles'. Secondly every supervisor should guide only a small number of students, which would not only improve his efficiency but also the students'. Thirdly, he should be made free of all administrative trappings.

Dr. Ladha laments that "quite a lot of time of active researchers in India is consumed in administrative work". Moreover, he adds, an Indian scientist does not get the

recognition he deserves. His own research concerns Cyanobacteria, or blue-green algae, a group of microorganisms, whose cells contain no definite nuclei. These microorganisms have a great potential, in that they had evolved in the primeval times, they resemble green plants and bacteria. Dr. Ladha has done research on one member of the group, *Nostoc*. His best research was, he says, done abroad. It was only because he could avail of the facilities available there, which improved the quality of his research work.

Born on January 5, 1952, in Gwalior, Madhya Pradesh, Dr. Ladha hails from a business family. He did his schooling at D.A.V. Higher Secondary School in Gwalior. After M.Sc. from Jiwaji University and Ph.D. from Benaras Hindu University, he joined the University of Dundee, U.K., in 1977 as a Commonwealth post-doctoral fellow. He says his interest in scientific research developed from a trivial incident during his childhood. One day he saw a line of ants going somewhere. Just for fun of it, he rubbed a spot between two ants. To his astonishment he found that the ants preceding the spot got confused. Why did the ants get confused? He asked his school teacher but he could not give a satisfactory reply. The incidence haunted him, and helped him to develop interest in science.

Dr. Ladha says that most of the people around him discouraged him from taking up research because

it is not a rewarding career. But he received "sufficient" encouragement from his science teacher and, later, his guide, Prof. H.D. Kumar, to sustain his interest and aspiration. He says that his research is a product of hard work. "Chance may help sometimes in research but not always". After doing research under Prof. W.D.P. Stewart, F.R.S. for one year in U.K., he returned to India in 1978. At present, he is a lecturer in the School of Biological Sciences, Madurai Kamaraj University, Madurai.

To popularise science and nurture scientific temper among students, Dr. Ladha says, inquiry and learn-through-fun methods, must be brought into us.

DILIP M. SALWI

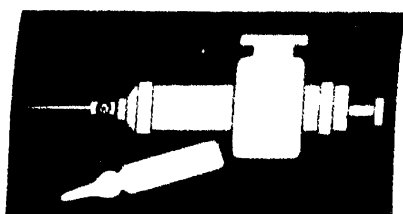
## Young scientists' meet

THE Society of Young Scientists at the All India Institute of Medical Sciences, New Delhi, is organizing a Symposium on 'Management of Indian Science for Development and Self Reliance' which will be held from Feb. 6-9, 1980. The topics: (i) Evolution and current status of instruments of science policy in India-critical analysis, (ii) Science & technology for development & self reliance, (iii) Management of research & development in research institutions & universities, (iv) Role of scientists in social change-proposals for future action.

The abstracts of the paper to be presented should not be of more than 250 words. The last date for receipt of abstracts is January 31, 1980. Except for those who have their own arrangements in Delhi, we are trying to arrange free boarding and lodging for the participants. N. N. MEHROTRA Convenor SYS Symposium 7/111, Ashwini Hostel, AIIMS, New Delhi-110016.



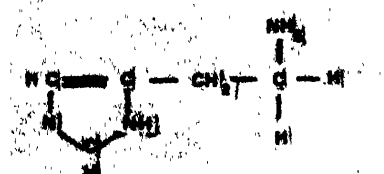
Dr. Ladha



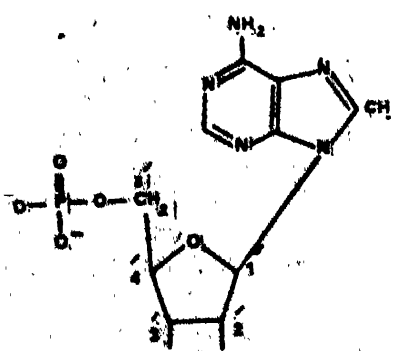
## MEDICAL NOTES

### Antihistamines

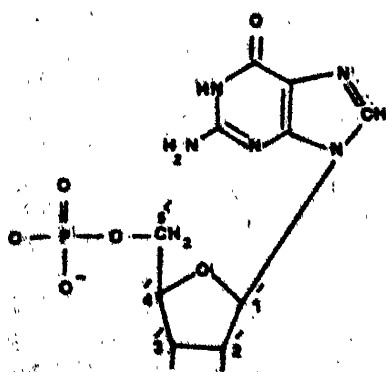
ALL are conversant with the word 'allergy'. This word brings



(I)



(II)



(III)

Fig. 1

to the mind irritating memories of a running nose, rashes and other manifestations that arise from allergy. Sometimes, these allergic manifestations appear as a bolt from the blue. However, many persons are unaware that the real culprit behind all these troubles is a chemical substance called histamine (I). Doctors, therefore, prescribe antihistaminic drugs to reduce and ultimately wipe off these allergic irritations.

To get an insight into the role of antihistamines, the meaning of the term 'Receptor' has to be understood. The dynamic, changing surface of the cell contains large floating molecules called 'receptors'. Hormones and other substances produced by the body fit exactly into the structure of these receptors. While some of these substances on attachment with the receptors trigger a cell-reaction which is conducive to the body, others generate a cell-reaction which causes irritation in the body. How is the cell-reaction initiated? As soon as a substance locks on to the receptor, the receptor immediately transmits signals to the interior of the cell through the messenger cyclic AMP (II) and cyclic GMP (III) to initiate cell-reaction. Cyclic AMP and cyclic GMP are nucleotides.

Now, if the initiated cell-reaction is not conducive to the body, the

person starts feeling sick and a drug has to be administered. The drug molecules replace the substance molecules locking onto the receptors. As soon as this happens, the messengers (cyclic AMP and cyclic GMP) again transmit signals to the cell-interior and the initiated cell-reaction is retarded and finally terminated. The physical turbulence annoying the person is thus pacified.

It has been found that when histamine molecules lock onto the receptors they bring about various allergic manifestations. The role of antihistamines lies in their locking onto receptors in various parts of the body and preventing the histamine molecules from gaining access to the receptors.

Antihistamines, however, have failed to cure peptic ulcers which were known to be triggered by histamine. This puzzled scientists for a long time until the discovery of another type of histamine receptor in the gastro-intestinal tract. After long experimentation, scientists have found a modified histamine molecule which could lock onto the new type of histamine receptor present in the gastro-intestinal tract and thus hinder the histamine molecule from doing the same.

CHITRA DATTA GUPTA

### Some antiamebic synthetic drugs

THE term "amoebiasis" in man may be defined as the infection caused to susceptible person with *Entamoeba histolytica*. It is a microscopic, one celled animal (Phylum : protozoa, Class : Rhizopoda, Family : Amoebidae) of about 25 microns (1/1000in) in diameter, a living

blob of jelly with a nucleus. It feeds on human tissues and it can breach and enter the lining membrane of the intestine. It reproduces by splitting into two halves, each of which grows into a mature amoeba. This easy parasitic life is possible only inside the human body. During an

attack of amoebic dysentery (amoebiasis) large number of amoebae are ejected in the stools and most of them die and the rest take on a new form becoming cysts, like the spores of some bacteria and other simple plants. A cyst is a round, inert body, usually with several (2-4) nuclei. It makes no demands on its environment, for it neither feeds nor reproduces. In this form the parasite can live for weeks without human company.

The disease is contracted by swallowing food (e.g., raw vegetables) or water contaminated with these cysts. This is most likely to happen in places where human excrement is used as manure, but unless ideal standards of hygiene are maintained amoebic dysentery can occur anywhere. It is common in the tropics and subtropics, and fairly rare elsewhere.

The symptoms of amoebiasis are much vaguer aches which may suggest appendicitis; feeling off-colour; occasional diarrhoea; and even constipation. The patient may go on like this for years, never really ill but never quite well. This, then is one of several diseases which can keep people who live in the tropics continually below par. The most important complication is the infection of the liver by amoebae which enter the veins of the intestine and are carried to the liver in portal vein. Amoebic abscesses may be formed, causing fever; and pain over the liver. Spread of infection from the liver to more distant organs (i.e., lungs, brain and genital) is also seen but rare.

Many drugs, most of them synthetic, are used as an amoebicide, a detailed account of them is given below.

### 8-Quinolinols

Three iodinated 8-quinolinols have been used for many years in the treatment of amoebic colitis (inflammation of the large intestine owing

ing to amoebiasis) namely : 7-iodo-8-quinolinol-5 sulphate (Chiniofon, A); 5-chloro-7-iodo-8-quinolinol (iodochloro-hydroxyquin, B) and 5, 7-diiodo-8-quinolinol (diiodohydroxyquinoline, C). These compounds are ineffective against extra-intestinal amoebiasis (in amoebic hepatitis) and their use is contra-indicated in patients sensitive to iodine.

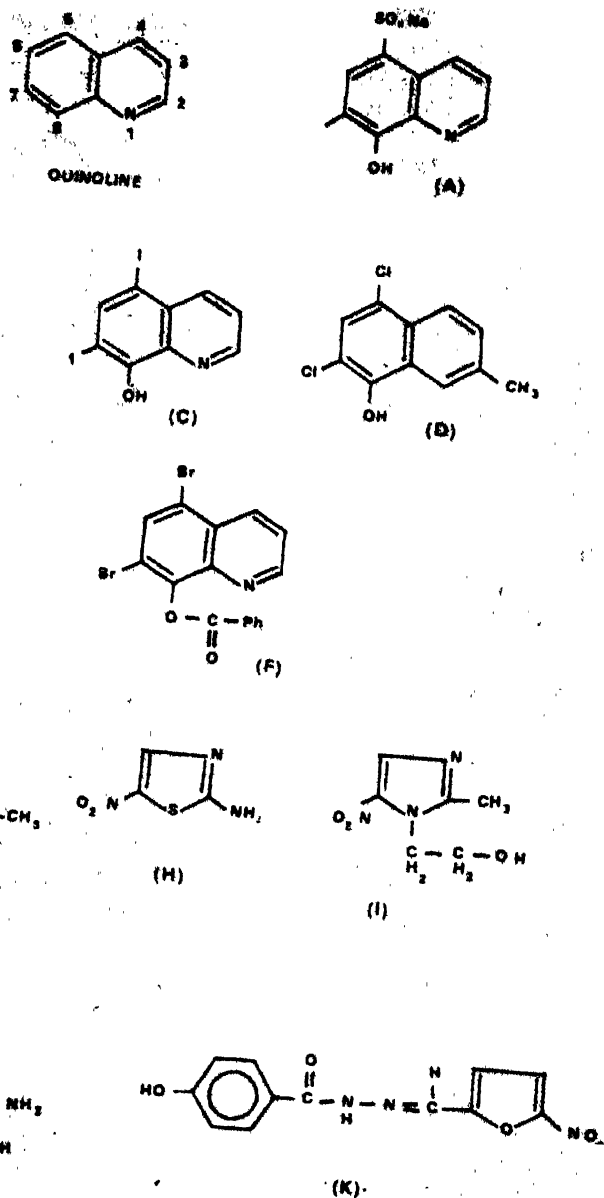


Fig. 1

The synthesis of sodium 7-iodo-8-quinolinol was first published in 1892 but its amoebicidal effect was discovered in 1921. 5-chloro-7-iodo-8-quinolinol and 5, 7-diiodo-8-quinolinol were introduced shortly after A and B.

Many non-iodinated 8-quinolinols are also highly effective against *Entamoeba histolytica* in man, name-



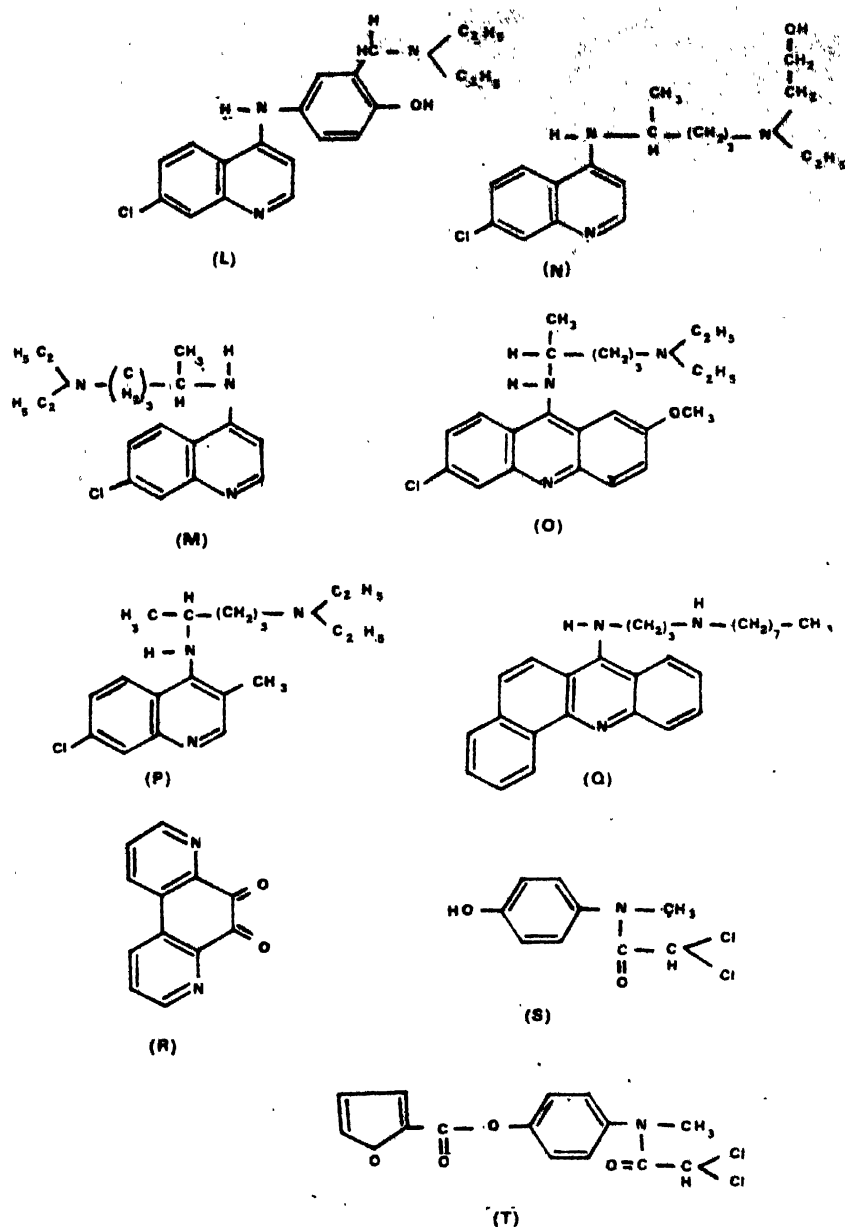


Fig. 2

ly: 5, 7-dichloro-2-methyl 8-quinolinol (Chloroquinoidol, D); 5, 7-dibromo-8-quinolinol (broxiquinoline, E). *Intestopan* is a combination of broxiquinoline and 5, 7-dibromo-2-methyl-8-quinol benzoate ester (brobenzoxaldine, F).

It was thought earlier that the mechanism of action of iodinated drugs are due to the release of iodine

in host but it seems unlikely that circulating forms of iodine are responsible for the efficacy of the iodinated 8-quinolinols in intestinal amoebiasis.

A relatively prolonged and uninterrupted treatment with halogenated hydroxyquinoline derivatives, used in high dosage for more than 14 days, have been reported to cause

peripheral neuritis and damage to the optic nerves in some cases.

### Nitro heterocyclic compounds

It was noticed twenty years ago that 2-acetamido 5-nitrothiazole (aminotrozole, G) cures intestinal amoebiasis in rats and dogs at well tolerated doses. Recently, a new 2-amino 5-nitrothiazole derivative (niridazole, H) with strong therapeutic effects against amoebiasis was discovered. The minimum inhibitory concentration of niridazole against *Entamoeba histolytica* *in vitro* is 10  $\mu$ g/ml. Results from recent human trials confirm that niridazole administered in daily dosage of 20-25 mg/kg for 5-10 days is highly effective against intestinal as well as hepatic amoebiasis but with some side effects.

2-methyl-5-nitro-1-imidazole-ethanol<sub>3</sub> (Metronidazole : *Flagyl*, *Metrogyl*, *Unimezole*, I) exhibits broad antiprotozoal activity. Metronidazole kills *Entamoeba histolytica* *in vitro* at concentration of 10  $\mu$ g/ml and has marked activity against intestinal as well as hepatic amoebiasis. It is given orally in 200 mg doses for 7-10 days, cured 95 out of 100 patients with acute amoebiasis of both forms. No toxic effects have been noted on the basis of results obtained.

Regarding the metabolism of metronidazole in man, urine contains 61%-69% unchanged metronidazole together with small amount of the corresponding acids (25%-26%) and a secondary metabolite, identified as the other glucuronide. No evidence was obtained about nitro group reduction.

In addition to the nitrothiazoles and nitroimidazoles, many other nitro heterocyclic compounds possess antiamoebic activity including nitro-pyrroles, nitropyrazoles, nitrofurans and nitropyridines. Among them 1-(2-hydroxy ethyl)-5-nitro-pyrrole-2-carboxamide (J) has promising oral activity against intestinal and extra-

intestinal amebiasis in rats and dogs. Ercefuryl (K) p-hydroxybenzoic acid-(5-nitrofurfurylidene) hydrazide is also found active against amoebic dysentery.

#### Other heterocyclic compounds containing nitrogen

Besides, antimalarial properties, amodiaquin (L), chloroquin (M), hydroxychloroquin (N), quinacrine (O) and santoquin (P) are effective against amoebic hepatitis in man but not useful in intestinal infections, presumably because they are readily absorbed and do not reach the lower intestine in required concentration. An efficient therapy for both intestinal and extra-intestinal amebiasis may be achieved by the judicious combination of one of these compounds with one or the more effective agents commonly employed in the eradication of intestinal infections. *Resotren*, *Amicline*, *Amoebiotic* are a combination of Tetracycline hydrochloride, Di-iodohydroquinoline and chloroquin phosphate and poorly absorbed due to low solubility and that is effective against both forms of amebiasis in man. Approximately half compound is broken down in the small intestine, remainder passes on to the large intestine where further cleavage occurs. Tetracycline is not a direct amoebicide but it alters the bowel flora on which amoebae live and di-iodohydroxyquinoline kills them. This combination is very effective when given orally for 7 days, and cures 90 patients out of

100. Continuous use of chloroquin is prohibited as it forms a complex with DNA and inhibits *in vitro* reactions catalyzed by DNA polymerase, RNA polymerase, and deoxyribonuclease. It also inhibits protein synthesis as its secondary effect.

Out of many 7-aminobenz (c) acridines synthesised for antiamebic evaluation, 7-3-(octylamino) propyl aminobenz(c) acridine (Q) was selected for expanded studies. *In vitro* potencies of (Q) and emetine against several strains of *E. histolytica* are comparable. The drug acts rapidly, and its effects are not appreciably reduced by protein; it is a direct acting amoebicide. On a weight basis (Q) is approximately 8 times as active as chloroquin against amoebic hepatitis and intestinal amebiasis in man and well tolerated.

#### Quinones

4, 7-Phenanthroline-5, 6-quinone (Phanquone : *Entobex*) has achieved wide acceptance as an intestinal amoebicide. *In vitro* phanquone is amoebicidal at 60mg/ml. and exhibits antibacterial activity against both gram (positive) and gram (negative) bacteria. In man phanquone is effective in treating both acute and chronic infections. A dose of 10 mg/kg daily appears to be maximum, since larger doses may cause gastrointestinal symptoms and smaller doses produce a slower therapeutic response. This drug is ineffective in hepatic amebiasis. It is reported that a combination of phanquone

and iodochloro-hydroxyquin (*Mexaform*) is more effective against intestinal amebiasis than phanquone alone.

#### Halo-acetamides

2,2-dichloro, 4-hydroxy-N-methyl-acetanilide (diloxamide, S) was the most active amoebicide of this series in rats and dogs but has low therapeutic value in acute amoebic dysentery. p-(2, 2-dichloro-N-methyl acetamide) phenyl-2-furoate (diloxamide furoate, T) proved to be outstanding in laboratory tests. It is approximately 10 times as potent as diloxanide. Clinically diloxanide furoate is more effective than diloxamide in the treatment of cyst passers and is considerably more effective in the treatment of amoebic dysentery.

No drug has yet provided complete cure of amebiasis and its total eradication is also not possible. However, simultaneous use of two or more drugs brought about 95% cure in cases of acute amebiasis of both types. Therefore, a drug combination therapy coupled with proper sanitary facilities and habits and care in handling of food prevent the transmission of the amoebae, but against the social and economic background of many tropical countries amoebic dysentery is unlikely to be eradicated for a long time.

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**IT PAYS  
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# SCIENCE FOR THE YOUNG

## How animals make food for us

**T**HE food that we eat comprises plant and animal products. The animal products provide abundant sources of all known food nutrients. They are rich in high quality proteins and are superior to plant proteins for man because they are better balanced in essential amino acids. Meat, milk and egg proteins are high in biological value and provide essential amino acids often deficient in plant foods. Animal products also contribute to man's needs for fats, carbohydrates, minerals, and vitamins.

All animals depend, directly or indirectly, upon plants for their supply of nutrients. The animal body is a remarkable chemical laboratory in which genes guide metabolic processes and utilization of foods. The digestive system of animals is designed in such a way that they can digest and utilize the foods normally consumed by them. The stomach of ruminants, such as cows, buffaloes, consists of four compartments, viz., rumen, reticulum, omasum and abomasum (Fig. 1), where microorganisms help in digesting cellulose and other compounds that cannot be broken down by the animal's own digestive enzymes. This enables them to uti-

lize large quantities of forages—grass, straw, etc. The ruminants are also able to degrade complex polysaccharides or structural carbohydrates of coarse fibrous feeds, food wastes and agricultural byproducts, etc., into edible nutritious products for utilization in their body. These animals serve as “middlemen” in converting many plants (which cannot be utilized directly by man), agricultural and industrial byproducts, etc., into animal products useful to man.

Interestingly, the service of these “middlemen” is aided by lakhs of tiny microorganisms present in their alimentary tract. The non-ruminants or ‘simple-stomached’ animals such as pigs, and poultry consume large quantities of grains and other concentrates.

In adult ruminant, the reticulorumen provides a favourable place for the growth of microorganisms, mainly bacteria which can live under high acidity in the absence of oxygen and at a temperature of 39°C to 40°C. Besides bacteria, various types of protozoa and yeasts are also present in appreciable amount. The bacteria in the rumen secrete enzymes which can degrade fodder, grass and other coarse fibrous feeds into edible nutrients. During the rumen fermentation, the carbohydrates are broken down and ultimately volatile fatty acids (VFA) such as acetic, propionic, butyric, etc., are produced. These fatty acids are responsible for supplying energy to the ruminants and fat synthesis in milk.

A portion of VFA is also used by the rumen bacteria for synthesis of their own polysaccharides. These bacteria utilize simple form of nitrogen, such as urea, to synthesize their cellular proteins. The urea,

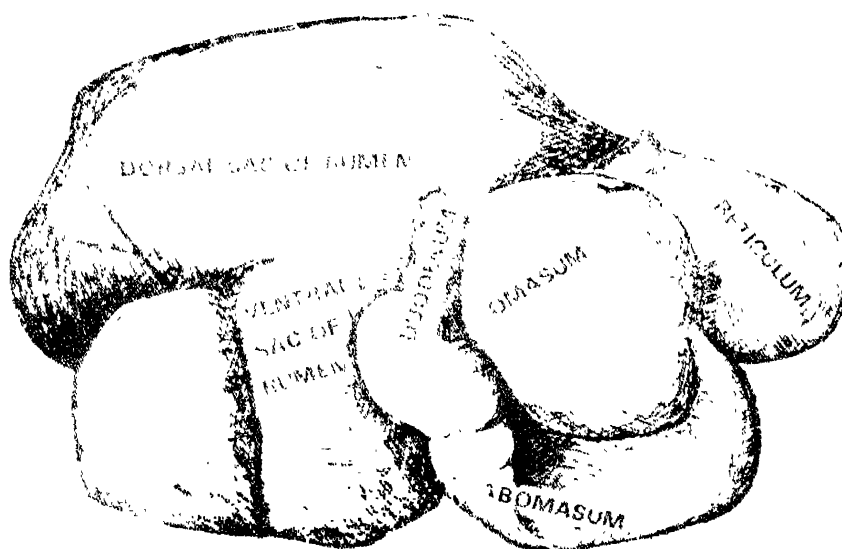


Fig. 1. Dorsal sac of rumen

is hydrolysed in the rumen with the help of an enzyme secreted by the micro-organisms into ammonia and carbon dioxide. Some part of this ammonia is used by the micro-organisms for synthesis of amino acids and proteins. The rumen micro-organisms ultimately pass into the abomasum and intestine, and are then digested by the host animal. The ruminants can also synthesize the essential amino acids and water-soluble vitamins of B group and fat-soluble vitamin K. The host animals therefore need not depend upon addition of vitamins in their diet.

The major portion of the diet of non-ruminants or simple-stomached animals like pig and poultry consist of agricultural byproducts of cereal grains, oil cakes, and animal byproducts such as meat meal, bone meal, blood meal, fish meal, etc., as the

source of energy, protein and other nutrients.

Poultry and pig can also digest small amounts of crude fibers and produce VFA in the lower part of the gut. (This generally occurs in caeca of birds and large intestine of pigs.) In addition they also synthesize vitamin B<sub>12</sub>. Recent findings indicate that the intestinal bacteria of pigs are also capable of synthesizing most of the other vitamins of B complex. So we see how animals, both ruminants and non-ruminants, all derive their nutrients from plants or animal byproducts and convert them into edible food for us.

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## How crystal bird works

YOU might have seen a funny-looking glass bird in shop windows constantly dipping its head into a cup of water. It creates a deceptive impression of being thirsty, drinking up the water continuously to quench its thirst. While the bird is in action, you might have noticed that its head first tumbles over, then the bird straightens out and finally sets itself into periodic oscillations. Have you ever wondered how it operates?

The crystal bird forms a closed, airtight system consisting of two glass or plastic bulbs H and B serving respectively as the head and the belly connected by a tube T (Fig. 1 a). The beak K of the bird is attached to head H and is covered with felt, a highly porous material capable of absorbing water. To make the bird, the two bulbs and the tube are first evacuated, then B is filled with a

highly volatile liquid such as ether, alcohol or freon and finally the

whole system is sealed off. The bird is pivoted at P near the middle of the tube T. As the centre of gravity (C. G.) of the system lies well below the pivot P the bird can swing freely.

When the head H of the bird is dipped in water contained in a beaker or cup C and then taken out (Fig. 1 b), water starts evaporating from the moist head H and cools it. This reduces the pressure of the volatile liquid inside the bulb H and as a result the liquid from belly B is forced up the tube T into the head. As the liquid rises up the tube, the C. G. of the system is shifted to a point above the pivot. It becomes unstable and the bird topples over. At this stage, the liquid flows back to the belly because pressure in both bulbs is equalised, and the system tries to regain its original stable equilibrium. You may notice that when the bird topples over, its head again dips in water. So when it becomes upright again, the head cools and the whole cycle is repeated.

The time between two successive dippings of the beak depends upon how fast the liquid rises up inside the tube and the rate of rise of liquid depends upon the rate of evaporation of water from the head. So, if the air

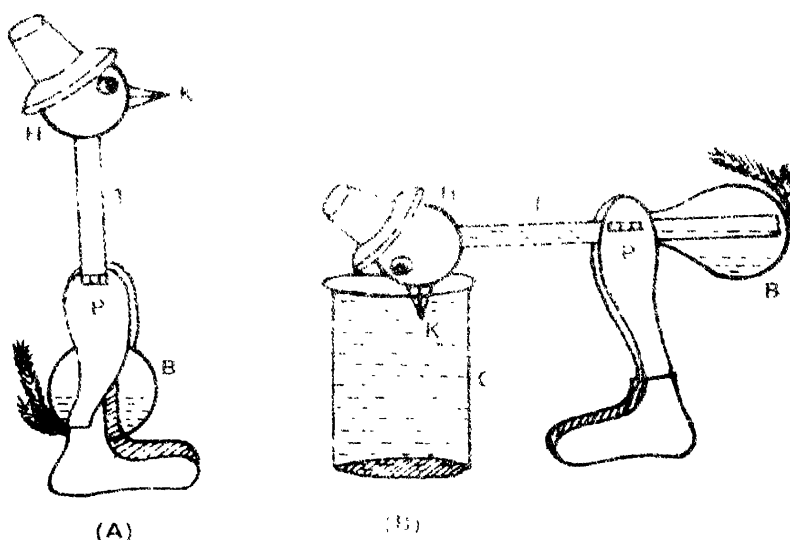


Fig. 1. Crystal bird (A), in operation (B)

is dry, or if we run a fan near the bird, or if we use alcohol or ether (which evaporate at a much faster rate than water) in the cup, the action of the bird can be speeded up. If it is covered in a glass case, the bird stops dipping after some time. This happens because the air inside the glass case soon becomes saturated

with water vapour, and no further cooling of the head takes place. On removing the glass case, however, the crystal bird resumes its operation once again.

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## Science quiz

- Hard waters have an excess of :
  - hydrogen ions
  - calcium and magnesium
  - nitrogen
  - sulphur
- Most abundant component of dry air is :
  - nitrogen
  - hydrogen
  - oxygen
  - carbon dioxide
- Carbohydrates are polymers of :
  - sugars
  - amino acids
  - fatty acids
  - nucleic acids
- Cellulose is found in :
  - bacteria
  - viruses
  - some animals
  - terrestrial plants
- Multicellular algae do not :
  - reproduce sexually
  - have holdfast
  - have a vascular system
  - have a stipe
- Microscopic, single celled aquatic plants are called :
  - abyssal
  - phytoplankton
  - hypolimnion
  - hydrophytes
- The light reactions of photosynthesis occur in the :
  - grana
  - stroma
  - outer membrane
  - nucleic acid of the chloroplast
- Heavy metals and long-lived pesticides are examples of :
  - toxic pollutants
  - waste products
  - nutrient wastes
  - both (i) and (iii)
- Eutrophication of a lake means, it
  - is low in nutrients
  - is high in nutrients
  - has a high temperature
  - has excess amount of organic matter.

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## Brain teasers

### 1. The mysterious page number

My mathematician friend Rajnikant has a fascination for celebrated works by great authors. Recently, he purchased a book that consists of four volumes. Each volume contains 500 pages. One day while going through the fourth volume, Rajnikant was amazed to see that a particular page number possessed some interesting mathematical properties. It was not only palindromic but remained unaltered when the page was seen upside down. Moreover, when the page was placed in front of a mirror, the image of the page number was a replica of itself. Can you guess what the page number was?

### 2. Eggs and the basket

A basket contains some white and some brown eggs. The total number of eggs in the basket is between one and five dozens. The white and the brown eggs are separately more than half a dozen in number. The number representing the eggs, when turned upside down, gives the product of the numbers of the white and the brown eggs. How many white and how many brown eggs are there in the basket?

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(Answers on page 28)*



## FOR HER

### Why a foetus is not rejected by the mother

**T**HE replacement of diseased organs by transplant of healthy tissues has long been an objective in medicine, but a serious problem in this method is the rejection of a graft tissue from the donor by the recipient. The ability of the body to recognise and combat with foreign materials (antigens) is known as 'immunity'. An antigen can provoke two types of immune response. Firstly, a particular type of proteins known as 'humoral antibodies' can be formed which are released into the blood stream to combat with antigens. The second type is the release of sensitized cells called 'small lymphocytes' which are effectors themselves. Their formation takes place in the lymphatic system of the body. It is the small lymphocytes that reject graft by infiltrating the donor's tissue and ultimately destroy alien cells. When an organ from one individual is transferred to another of the same species the graft is known as an 'allograft'.

The immune responses have a genetic basis. One genetic region in the chromosomes of the higher

vertebrates known as the 'major histocompatibility complex' (MHC) exerts a profound influence upon rejection of grafts by controlling the synthesis of antigens in the donor organ which can provoke severe immune responses in the recipient. This will not happen in the case of identical twins or animals of closely-bred strains which incidentally possess similar antigen producing genes and therefore no immune response is possible. The MHC consists of H=genes known as H-loci.

#### The fetus as an allograft

An embryo, which is formed by the union of father's sperm and mother's ovum, inherits half the genes from the mother and half from the father. Therefore it is genetically distinct from each parent. After the embryo gets implanted inside the mother's womb, it is in intimate contact with the parent's tissue. At this stage, it may be regarded as an allograft. Surprisingly, reproduction seems to be a perennial success. How is it that this allograft is not rejected by the mother?

There are several possibilities which may be considered. The fetus might be protected by half the genes that it has inherited from the mother. Had this been true, a mother's organ transplanted in the fetus of an organ transplanted from the fetus to the mother would not be rejected. But frequently sons reject mother's organ. By inheriting half the genes from the mother and half from the father, the fetus has an entirely different MHC from the mother. It has different transplantation antigens which can induce immune responses in the mother leading ultimately to embryo rejection.

The second possibility is that the uterus may be an immunologically privileged site, that is, it is somehow protected from immuno-

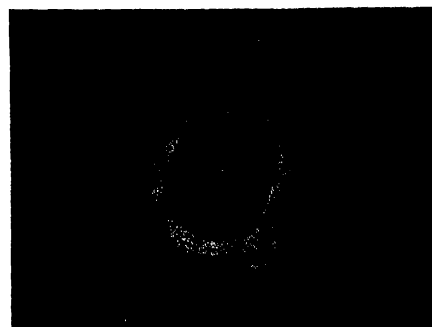


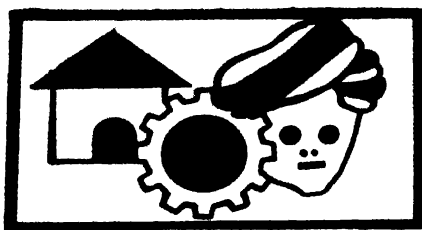
Fig. 1

logical reactions like the brain and the anterior chamber of the eye which can retain allografts for quite a long time. These sites have in common a paucity of draining lymphatic vessels. Therefore the tissue grafted to them is not destroyed quickly. Antigenic material is not transported to the lymph nodes and sensitized lymphocytes are therefore not produced. It has been observed that uterus is well supplied with lymph vessels and antigenic materials released into uterine allografts do reach them and provoke immunological responses.

Another possibility is that the mother might be inert to fetal tissues. But this is not the case as is shown by the incompatibility of the Rh factors (rhesus factor). This factor is an antigen which is present in the red blood cells of many human beings. They are called Rh<sup>+</sup> while those who lack the factor are known as Rh<sup>-</sup>. When the mother is Rh<sup>-</sup> and bears a child which is Rh<sup>+</sup> by inheriting the gene, determining the factor from the father, then the fetal erythrocytes migrating through the placenta (an organ formed to supply nourishment from the mother to the fetus) will provoke production of antibodies to them in the mother. These antibodies in turn would cross the placenta, reach the fetus and destroy foetal red blood cells causing a fatal illness.

(Continued on page 13)

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## TECHNOLOGY FOR VILLAGES

### Technology for walnut processing

**T**HE walnut processing technology developed and tried out successfully by Central Food Technological Research Institute (CFTRI), Mysore during the last three seasons modernises time consuming traditional operation and improves the quality of walnuts. This can help boost export of walnuts. India ranks fifth among walnut growing countries and exports around 8,000 tonnes of walnuts annually valued at Rs. 30 millions.

There is scope for stepping up export if the quality of dried walnuts are upgraded by improving and modernising the traditional processing techniques.

In traditional techniques, green walnuts, soon after harvest, are heaped in the open in 200-500 kg. lots, covered with walnut leaves and periodically sprayed with water to prevent any possible dehydration. After about seven days, they are hulled manually by cracking with small stones or mallets; the split hull is separated by hand. The dehulled nuts are washed in streams and later sun-dried for 7-8 days. In these operations, large black spots and dark colour develop in the kernels and shells which fetches low prices in international markets. These defects have been overcome in the CFTRI technology.

In the CFTRI process, freshly harvested green walnuts are first conditioned to loosen the husk by stacking them in large wooden trays, measuring 1 m × 2 m × 0.3 m with wooden grate bottom and covered by polyethylene sheets with punched holes for aeration for 4-6 days. The trays, each of which can hold about 200 kg of walnuts, can be placed either outdoors or indoors.

The conditioned walnuts are mechanically dehulled in a machine powered by a 0.5 H. P. motor which can process 500-600 kg. of green walnuts/hour with the help of a single operator for picking out hulls.

A manually operated washing machine and an electric powered washing machine have been developed and standardized for washing dehulled walnuts; they are then dried in a bin drier with a capacity of 500 Kg/batch. The drying time has been reduced from 7-8 days to about three days where the air temperature is maintained at 38-40 C. A three stage drier with brick construction has also been developed.

A model plant for processing one tonne of green walnuts/day involves an initial investment of Rs. 25,000/- and a recurring expenditure of Rs. 8,000-10,000.

## Protection of foodgrains

**P**ROTECTION of stored foodgrains from ravages of insects, rodents and microorganisms has been an important research activity in CFTRI.

Methods of grain storage evolved by CFTRI are being adopted by both private and public sector organisations to minimise food losses. Over 30 pest-control service organisations are now operating in the country with the help of technology, consultancy services, and training provided by the Institute.

For protecting commercial stocks of foodgrains stored in warehouses, CFTRI's Durofume Process of fumigation which destroys insect pests at every stage of development and prevents fresh infestation, has proved economic and successful.

Sample small scale fumigation methods have been developed and demonstrated to destroy insects that live on cereals, pulses and seeds stored in containers such as mud pots, metal vessels, cardboard boxes and tin cans. The fumigants are formulated as tab-

lets, sticks and ampoules for convenient use in different situations. They can also be used effectively to disinfest grains stored in comparatively bigger containers such as polythene bin, metal bins, indoor plywood structures and underground pits.

Even after fumigation, bagged commodities can be attacked by fresh batches of insects from outside. This can be prevented by insect-proofing of jute bags, in which grains are usually stored, with specially formulated emulsions using an easily fabricated and operated machine that can treat 400 bags per hour at a cost of 30 paise per bag. Several rural co-operatives and regulated markets have been using this technique for the past few years.

Different types of small scale storage structures made of clay, plywood, plastic, ferrocement, metal and RVC have been evolved by the Institute in collaboration with other research institutions in the

(Continued on page 71)

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# Science in Industry

## Electronic instrumentation for sugar industry

**U**NDER a grant-in-aid project funded by the Department of Electronics for the development of electronic process control instrumentation for sugar industry, the Central Electronics Engineering Research Institute (CEERI), Pilani, has developed electronic control instrumentation for two of the most critical stages in the sugar industry, viz., juice clarification and pan boiling. The National Sugar Institute, Kanpur, is paying attention to the sugar technology aspects and coordinating the testing of the instrumentation in some commercial sugar factories.

In the juice clarification stage, the automatic liming and pH control instrumentation continuously senses the pH of the sulphited juice and controls automatically the rate of flow of milk of lime so as to keep the pH close to an optimum set value for clarification of juice. Field trials of the prototype units in some commercial sugar factories have shown that the control system maintains the pH with an accuracy far exceeding that in manual control ( $7.0 \pm 0.15$  vs  $7.0 \pm 0.8$ ).

Such an accurate control of pH on sulphited juice indicated: (i) improvement in mud settling rates; (ii) reduction in CaO and MgO contents in the clarified juice; and (iii) rise in the pol content in the clarified juice. This is also expected to indirectly help in reducing the losses due to inversion.

Another important process stage where control instrumentation finds a very wide application is the vacuum pan boiling stage. One requires to monitor continuously the degree of supersaturation of the mother liquor and to assess the various critical stages in the pan boiling, viz., seeding, hardening, thinning and final pan dropping, and thereby control the boiling of the strike by regulating the feed of molasses/water. CEERI has developed an instrument, named Panometer, which monitors the ac resistivity of the boiling sugar massecuite in the pan. This is directly related to the degree of supersaturation of the mother liquor.

Field trials of prototype units of both instruments in some commercial sugar factories have indicated improvements in fuel economy (by reducing the boiling period by about 25%), uniformity in crystal size, and reduction in sugar losses.

### Workshop

The laboratory organized a workshop on 'Electronic process control instrumentation for sugar industry' during 21-25 September 1979 at Pilani.

Laboratory demonstrations on (i) digital set-point proportional controller; (ii) automatic liming and pH control system; and (iii) panometer were arranged for the delegates.

The delegates deliberated on the role of electronic process control instrumentation and systems, particularly in the sugar industry, and identified the following areas in which instrumentation would be valuable: (i) automatic lime feed control

for juice clarification; (ii) pan boiling system (graining and massecuite boiling); and (iii) vacuum evaporators.

The workshop felt that electronic instrumentation was also desirable in the following areas: (i) electronic weighing system for juice, cut-cane and bagasse using a belt conveyer weighing system; (ii) automatic control of sulphur dioxide; (iii) juice flow control; (iv) vapour line juice heater (temperature); (v) treated juice heater (temperature); (vi) clear juice heater (temperature); (vii) crystallizers (temperature); (viii) sulphur burner (temperature); (ix) mill drives (solid state ac drives); (x) cane carrier (solid state ac drive for autocane); (xi) centrifuges (variable speed solid state ac drives); (xii) steam (flow); and (xiii) boiler feed water control (pH) conductivity.

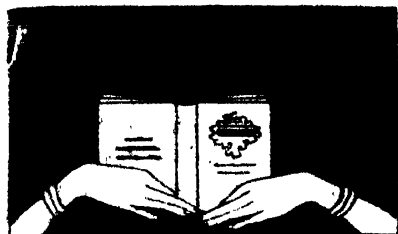
There was a suggestion that recorders or digital printout systems may be introduced for recording the critical variables such as temperature, brix, flow, and pH.

The representatives of the sugar industry and the experts in the field also suggested that: (1) The possibility of introducing low-cost instrumentation in the Khandsari sugar factories should be explored; and (2) Hand-operated mechanical scrapers (semi-automatic type) should be used for scooping out the pulp after slitting the cane into two halves so as to achieve effective saving of energy in crushing, milling, etc., and better clarification efficiency.

## CGCRI develops glass ceramics

**T**HE Central Glass & Ceramic Research Institute (CGCRI), Calcutta, has developed, on laboratory

(Continued on page 71)



## BOOK REVIEWS

**BIOLOGICAL IDEAS IN POLITICS** by W. J. M. Mackenzie, *Penguin Books*, Harmondsworth, Middlesex, England (Indian Agents: *Penguin Overseas Ltd.*, 706, Eros Apt, 56 Nehru Place, New Delhi-110024), Pp. 93, 90 p.

IN recent years behavioural sciences have become extremely important and connect both natural sciences and social sciences. Adaptivity, which is nature's most important principle for the successful survival of living organisms, has been extensively exploited by political scientists, sociologists, and philosophers, and Mackenzie's book under review is a well qualified essay on political adaptivity. Man—a rational thinker and an integral part of nature and subject to chance like other living creatures—has undergone repeated selection procedure by nature and become extremely successful for his advantage. But the crucial and controversial point is raised whether his success is due to biological adaptation or social adaptability. The concept of Social Darwinism is being pursued to envisage the successful establishment of man and the implications of this doctrine is analyzed by philosophers, sociologists, political scientists, anthropologists and biologists.

The book has been divided into six chapters including Introduction; The Natural History of Man—an orthodoxy; The Critics; Limits of Growth; The Choice of Futures and Institutions of Adaptivity. There is a post script running into five pages. Thomas Szasz's (The Second

Sin) ideology "in the animal kingdom rule is, eat or be eaten; in the human kingdom, define or be defined" is apparently fairly well traced through the course of discussion and forms a framework for the possibility of social adaptivity concurrent with biological adaptivity. The author, a well-known political and behavioural scientist, has successfully tried to weave the concepts from several classics, for example Walter Bagehot's *Physics and Politics*, Graham Wallas' *Human Nature in Politics*, Eliot Howard's *Territory in Bird Life*, Richard Dawkins' *The Selfish Gene* and James Watson's *Double Helix*. The reader is thus simultaneously exposed to multiple concepts of adaptivity converged to a single write up and the interpretations followed can be well judged.

The book is handy and the text, though interesting, is at times difficult for its rhetoric and style. Nevertheless, it forms an informative text for a common man and also for a specialist.

KESHAV TREHAN

**A TEXTBOOK OF APPLIED CHEMISTRY** For Home Science and Other Sciences by Thankamma Jacob *Macmillan Co. of India Ltd.*, 2/10 Ansari Road, Daryaganj, Delhi-110002, 1978, Pp. xiv + 415, Rs. 25.00.

EVEN in this twentieth century, it is surprising how few of us, even among the educated, are aware of the multifarious role that chemistry plays in our day-to-day life. Be it simple cosmetics, drugs, clothings, fuel, food or the host of plastics, alloys and things that we use daily—they are either chemicals themselves or products of some chemical process. But unfortunately not many books are available which can guide the common man in this matter. Most textbooks of chemistry fail to highlight the practical aspect of the

subject, being confined to the academic side—such as preparation, properties and uses of chemical substances and so on. The result is that most students look upon chemistry as a drab, uninteresting subject—one that is only equations to be crammed. On the other hand, we find consumers and housewives, even the educated among them, totally ignorant of even the simplest facts about things like cooking gas, synthetic fibres, medicines, food products, cosmetics, to name a few. Thankamma Jacob's book amply fills the gap. It provides in a reasonably compact yet lucid form the chemistry of the various items of daily use and at the same time tells us about their applications in everyday life.

The field covered in this single volume is surprisingly vast—ranging from common drugs, essential oils, perfumes, flavours, cosmetics, and household fuels to metals, plastics, pesticides, food and environmental pollution. Each one of its fifteen chapters covers some aspect of applied chemistry in our daily living and suggests ways for proper selection and safe use of things like medicines, cosmetics, utensils, textiles, pesticides, etc. Over 65 Tables (including 10 in the Appendix) give useful facts and figures about various items of common use—domestic fuels, metals, alloys, plastics, synthetic fibres, textile dyes, pesticides, common food toxins, effects of impurities in water, and many more. There is a separate chapter on "fire prevention and protection in homes" which gives useful tips for extinguishing various types of minor fires at home. Wherever possible, drawing upon her own experience, the author makes critical evaluation of various marketed consumer products which should be welcomed not only by the student but by any consumer. There is a comprehensive index for quick reference.

Considering the contents of the book, I feel its title is a bit misleading. It is unlike any ordinary "text-

book" we come across in the bookshop. It is more a popular handbook, written in a style that should be understandable to any intelligent reader. Though meant basically for students of home science, the book will be a valuable guide for anyone who wants to be well-informed.

BIMAN BASU

**THE INTERPRETATION OF QUANTAL RESPONSES IN BIOLOGY** by P. S. Hewlett and R. L. Plackett, *Edward Arnold (Publishers) Ltd.*, London (Available in India at *B. I. Publications* 359, Dr. D. N. Road, Bombay-400032), Pp. 82, £ 3.95.

A scientist gives a particular quantity of a poisonous drug to a mouse and is interested to know whether the mouse is dead or alive (and not any quantifiable effect). He is said to be looking into a quantal response.

The book under review is about the statistical analysis of the type of responses on organisms. The authors start with a discussion of a typical dose-response curve. This curve has been empirically observed to be similar to the cumulative lognormal distribution function. With this fact in mind the authors develop the theory of standard Probit (short for probability unit) transformation. A separate chapter is devoted to the calculations in Probit analysis.

At times a log-dose-response curve can be better approximated by the cumulative logistic distribution function. For this case the authors elucidate the theory of standard Logit transformation along with the practical calculations involved in the Logit analysis.

Sometimes, a mixture of drugs is administered to an organism. The different drugs affect the organism jointly, additively or otherwise. A chapter is devoted to the study of a variety of mathematical models

involving the measurement of the joint effects. These models are rarely tackled in the books on biostatistics because of their complex structures. In this context a special mention must be made of the models based on the drug-receptor theory which have been elegantly formulated in the book.

Another outstanding feature of the book is the analysis of quantal responses in heterogeneous populations. Scientists often encounter groups of genetically different insects some of which are highly resistant to an insecticide and some quite susceptible. The statistical tools necessary for such analysis have been indicated in the book.

When the time lag between druging and response decreases with increases in doses, time becomes an important variable. A brief sketch of time-response theory is followed by a short discussion of the link between the quantal and graded (quantifiable) responses.

The only drawback of the book is that the intuitive explanations of the concepts tend to be short and sketchy. These explanations are followed by precise formulation of the concepts for mathematically inclined readers. The nicely produced paper-back is amply endowed with diagrams and tables wherever necessary. So, the book is useful for a wide range of scientists, including the biologists designing experiments in laboratories and the statisticians interested in developing the tools further.

RAVINDRA R. RANADE

**AN INTRODUCTION TO ENERGY CONVERSION VOL. II — ENERGY CONVERSION CYCLE; VOL. III — TURBOMACHINERY** by V. Kadambi and Manohar Prasad, *Wiley Eastern Limited*, AB-8, Safdar-jang Enclave, New Delhi-110016 Pp. 312.

THE second of the 3-volume set introduces in a comprehensive

the fundamentals of the subject, "Energy Conversion". It can well serve as a text book on the subject for the undergraduate curricula. It follows the contemporary approach and is a welcome addition to the indigenous text books on engineering subjects.

It is commendable on the part of the authors to present the subject in a simple and generalized perspective. Unlike the conventional texts on 'Heat Engines', the book lays more stress on elucidation of basic principles without getting bogged down at specific handwork. The opening chapter contains an interesting resume of the indigenous energy sources. The general principles of thermal energy release, including combustion and nuclear reactions are given. The rest of the book is devoted to the presentation of important characteristics and application of various energy conversion cycles. Sufficient number of well selected problems are also given. If the treatment had been more rigorous it would have been an useful text book.

Like the first two volumes, the third one deals comprehensively with various types of turbomachines. The authors have made a commendable effort to present in a unified and coherent manner the basic theory and guiding principles of the apparently diverse types of turbo-type energy conversion devices.

Various applications of turbomachinery, such as steam and gas turbines, centrifugal and axial fans, blowers and compressors, hydraulic pumps and turbines, etc., have been given. The maze of specific hardware details has been avoided. However, number of relevant problems have been solved to illustrate the application of the accompanying theory. Along with the other two volumes, this volume will be helpful in updating and improving the quality of teaching of energy conversion systems.

RAM NARAYAN

## BOOKS RECEIVED

1. **FOOD, ENERGY AND SOCIETY** by David and Marcia Pimental, *Edward Arnold*, 41, Bedford Square, London, WC 1B 3DQ, England, Pp. 165, £ 3.95
2. **MODERN PHYSICS AND QUANTUM MECHANICS** by E. E. Anderson, *Macmillan Co. of India*, 2/10, Ansari Road, New Delhi-110002, Pp. 430, Rs. 24.75.
3. **SCIENCE OF ENGINEERING MATERIALS** by Manoj Chandra, (Vol. I & II), *Macmillan Co. of India*, (address same as above), Pp. 264, Rs. 15.25 and Rs. 15.50
4. **GYMNOSPERMS** by O. P. Sharma, *Pragati Prakashan*, P. B. No. 62, Meerut-250001, Pp. 254, Rs. 15.30
5. **TEXT BOOK OF ALGEBRA**, Leadership Project Committee, University of Bombay, *Tata Mc Graw Hill Publ. Co. Ltd.*, (12/4, Asaf Ali Road, 3rd Floor, New Delhi-110002) Pp. 176, Rs. 15.00
6. **AN INTRODUCTION TO ANIMAL ECOLOGY** by H. R. Singh, *S. Nagin & Co.*, 6-U. B. Bungalow Road, Delhi-110007 Pp. 205, Rs. 10.00

## SCIENCE IN INDUSTRY (Continued from page 68)

scale, a transparent glass-ceramics which has zero thermal expansion within the temperature range 20-300°C. The glass is from high silica region of  $\text{Li}_2\text{O}-\text{Al}_2\text{O}_3-\text{SiO}_2$  system with minor amounts of alkali oxides,  $\text{TiO}_2$  and  $\text{ZrO}_2$ . On melting, the glass becomes transparent and pale amber in colour with a coefficient of thermal expansion of  $40-60 \times 10^{-7}/^\circ\text{C}$ .

Thermal crystallization of the glass within the range of 700-850°C yielded ultra low-expansion ( $\pm 1.0 \times 10^{-7}$  between 20°C and 300°C) transparent glass-ceramics. The glass-ceramics has beta-quartz solid solution type crystals. The crystals are smaller than the wavelength of the visible light and have low bi-refringence. The difference between the

refractive index of the residual glass in the glass-ceramics and that of the crystals is very small.

This type of transparent glass-ceramics with zero thermal expansion is suitable for making mirrors for astronomical reflecting telescopes. This glass-ceramics can be used with advantage as an image intensifier in passive devices employed in defence.

## TECHNOLOGY FOR VILLAGES (Continued from page 66)

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Rats are another serious threat to our foodstuffs, and to control their menace, intensive studies have been carried out. An integrated technique based on fumigation of

rat burrows, and combined use of novel repellents, selective improvised poisoned baits has been suggested for keeping the rodent population under control.

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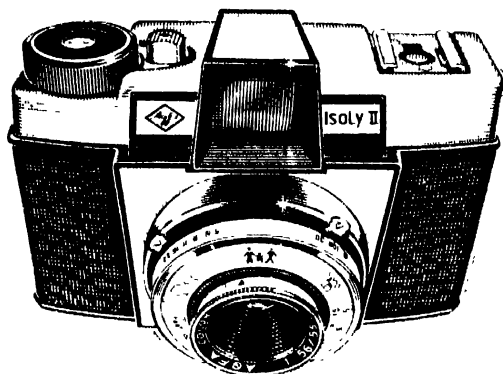
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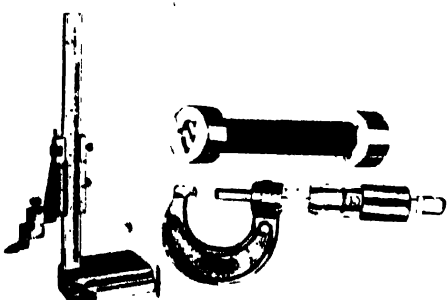
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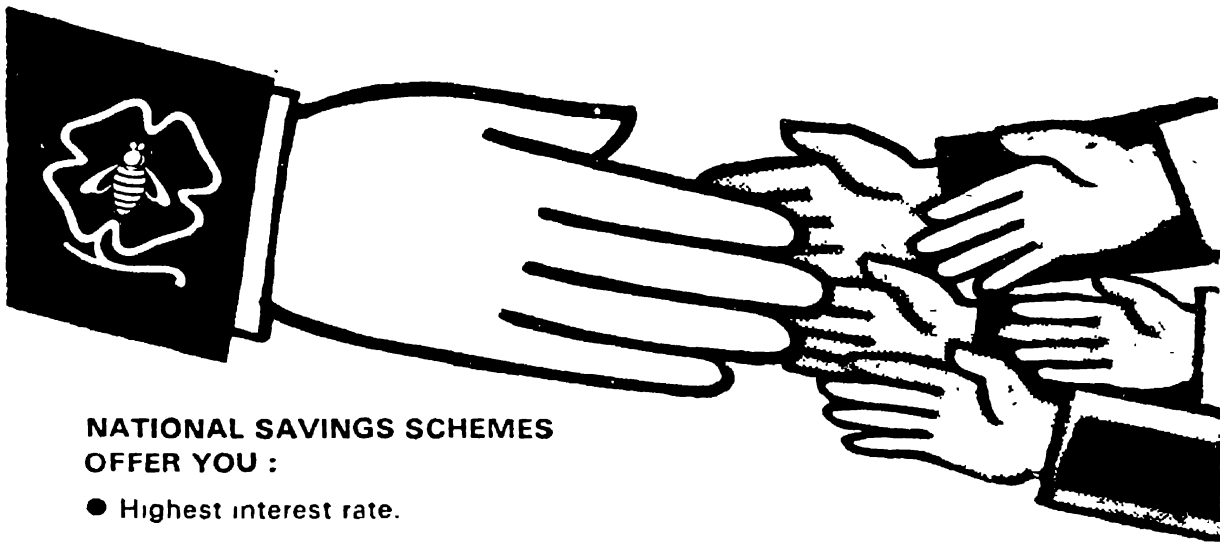
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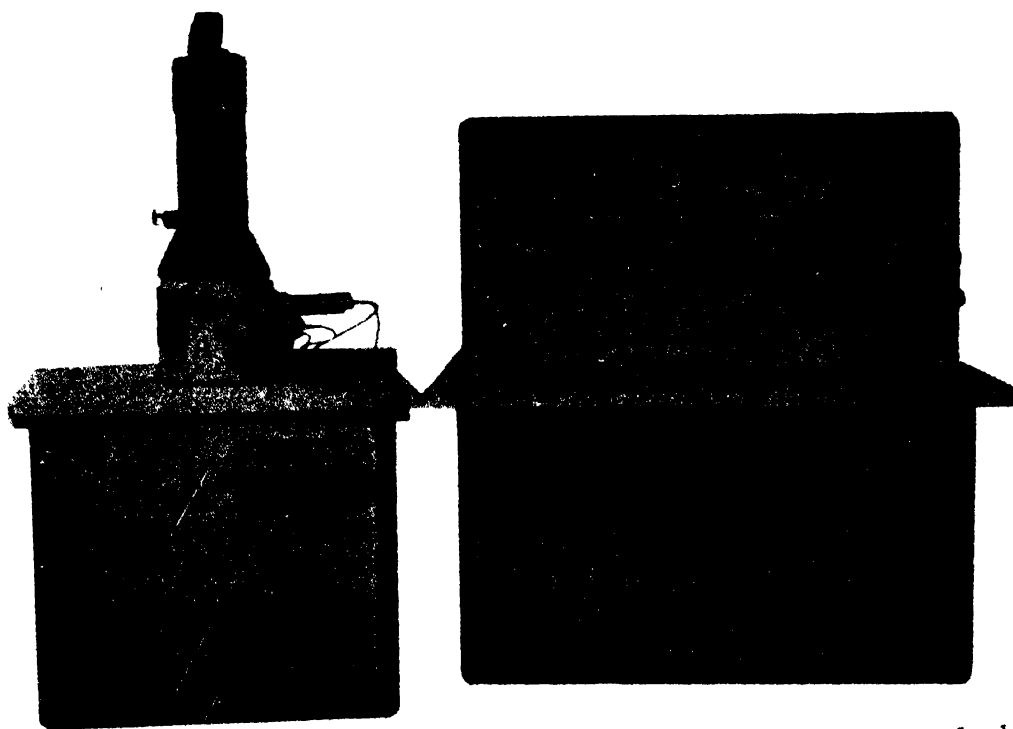
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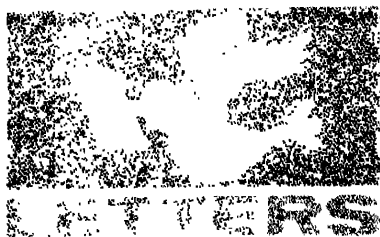
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All In The Head—Progress in Polymer Science—Chemistry Objective Tests—Momentum Transfer Operations

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### Gorilla food for people : a fantasy ?

Sir, This letter is not intended as a scientific contribution but may add a colourful human angle. I have had many enjoyable hours reading *S.R.* ever since I discovered it in our University library a year or so ago, though it arrives months late. Many things in it cause me to exclaim "Wow ! I never knew that was so. How interesting !" I commend the work you are doing in popularising science, especially to a mass (I hope) Third World audience. I am especially interested in articles which try to discover or illuminate the scientific basis of traditional cultural practices of peoples, in contrast to trying to keep up with the latest dazzling and sophisticated gadgetry produced by western technology, though I do a bit of that too.

In this letter I will make a whimsical comment on the article *Food habits of mountain gorilla* (*S.R.*, October 1978), and especially on the "Mufumba" plant. I happen to come from a village in the mountains of which the article speaks, and am rather familiar with the plant. Not from scientific studies, which I have not done, but from having grown up with it as a goat-boy and rather thirsty and hungry school-boy.

The author speculates that "the stalks of *Mufumba may* (*italics mine*) be edible." I confirm that the stalks are indeed edible, as I have eaten them. The sample shown in the picture is too old and so not juicy enough, but, if you are really thirsty

you may eat it. However, the perfect gourmet sample is the young, fleshy, tender and delicate sapling (may be only 30cm high). You pluck it, strip the bark off (if you are finicky or not too thirsty) because that is where the sourest taste is; then you chew it and swallow every thing, enjoying the sharp refreshing juices. As kids we could never have enough of it, though adults scoff at it, as they do at many wild-growing but delicious knickknacks. Of course education based on proper scientific knowledge of the benefits would change such attitudes.

I know two types of *Mufumba* myself. The one pictured in the article has a hollow stem, akin to bamboo or castor plant. The other, also quite edible, has thin, pointed leaves and a fleshy, non-tubular stem. The imaginative uses of which *Mufumba* is or might be put to are fascinating. I will be interested to hear of the progress made in this area.

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### Mt. Everest

Sir, In *News & Notes (Geography of Venus)* of *S.R.*, Sept. 1979, R. K. Datta mentions the height of Mount Everest as 8708 m. A children's book of geography gives the height as 8848 metres. Collins *New Gem Dictionary* (pocket-size) gives the height of Mount Everest as 29,141 feet. Calculating we get the height of Mount Everest as 8882.17 m approx. Kindly enlighten me as to which figure is correct. Incidentally, readers of *S.R.* accept the figures and facts reported therein as correct in comparison to other sources which may be out of date. Please ensure that figures given by contributors are thoroughly rechecked by your staff so that credibility of *S.R.* is never

allowed to suffer.

D. PRASAD  
Kanpur-208012

### Papaya and vitamin A

Sir, Re: Is papaya teratogenic? by Prasanta Kumar Mitra (*S.R.*, Sept. 1979), I would like to add the following points.

That vitamin A is teratogenic does not seem to have been realised by many medical practitioners. I have come across doctors asking the patients to take one or two capsules of the preparation three times daily—even in the case of pregnant ladies. I have seen on more than one occasion its disastrous effects on the growing foetus. Though I am not in the medical field, I have seen the ill effects of such overdoses. Even on the cartons of the proprietary preparations, the dosage recommended, I feel, is rather too high.

Whether pregnant or not, hypervitaminosis due to vitamin A in any form, including cod liver oil, is harmful. I have heard of social service organisations administering vitamin-A capsules in children's centres, and some of the above organisations connected with research were actually experimenting in some of the children's schools whether large doses of vitamin A could be stored in the liver, thereby ensuring against any vitamin-A deficiency in later stages.

It is high time that you make one of the experts in the field give a detailed account of the harmful effects of overdoses of vitamin A and it will be doing great service to the public.

Milk is good, but it is too much of a good thing for a kitten having fallen into a tub of milk.

A. V. KUPPURATHNAM  
Asstt. Professor of Chemistry  
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Coimbatore 641014

## B-chromosomes

Sir, I have read with interest the article by Karen S. Arora and Subhash S. Arora **What are B-chromosomes?** (*S.R.*, August 1979), and would like to add the following :

(i) Bs are found more commonly in plants than in animals. The advance families like *Gramineae* and *Compositae* have more number of Bs than the primitive families like *Malvaceae*, *Rosaceae* and *Juncaceae*, and so there might be a possible relationship between Bs occurrence and the degree of evolutionary advancement of angiosperm.

(ii) Bs are rarely found in inbreeding species. Information assembled by Moss (1969) suggests that there is a strong correlation between the occurrence of Bs and a tendency to out breed. The reason is that forced inbreeding of a naturally outcrossing species, with Bs, rapidly leads to decline in their frequency. In rye, inbred by repeated selection and intercrossing of 2-B containing plants over nine generations, the frequency of Bs was reduced from an average of 2.2 to an average of 1.4 per plant.

(iii) The Bs appear to occur in highest number under circumstances most favourable to the existence and growth of the species.

(iv) Roades and Dempsey (1972) postulated that Bs have negative effects upon cell activity by competing for nucleic acid precursors and amino acid needed for their replications. This in turn leads to reduce nuclear genetic activity and extension of mitotic cycle time; and ultimately gives rise to an impaired growth and vigour.

(v) Of course, even-numbered combination of Bs, have the least effect on vigour and nuclear metabolism. Jones and Rees (1967) postulated that the effect might result from a "contiguity effects" between Bs, such that paired combination act more frequently than unpaired one.

(vi) Evans and Macefield (1973)

found that in the diploid inter specific cross *Lolium temulentum* and *L. perenne* +B, the Bs suppress pairing and chiasma formation between homoeologous chromosomes. In the absence of Bs, pairing and chiasma formation are very regular. At the tetraploid level, pairing is confined to homologous pairs of chromosomes only, when Bs are present, resulting in exclusive bivalent formation at metaphase I. Without Bs, quadrivalent associations are found at metaphase as a consequence of pairing between homoeologous and homologous chromosomes.

(vii) Certain members of the normal A chromosome complements possess large heterochromatic knobs at specific sites in the chromosome arms. When two or more Bs are present in a plant the arm or part of arm carrying the knobs are frequently eliminated at meiosis II. Little or no loss occurs in microspores with one B, and the rate is not increased with more than two Bs. A-chromosomes that lack heterochromatic knob are stable in their heritance.

(viii) The evolutionary origin of accessory chromosomes is still largely a matter of hypothesis and conjecture. The fact that, with few exception, they show no signs of homology with chromosomes of the basic set, and are completely different in size and morphology, suggest that in most species which have them, they are not recently derived from the basic chromosomes.

MD. ZAFFAR HASSAN  
P. G. Department of Botany  
Magadh University  
Bodh-Gaya

## Female sex hormone

Sir, The problem of gastric ulceration and its protection by female sex hormone has been aptly discussed by Prasanta Kumar Mitra in the article **Does female sex hormone save women from ulcer?** (*S.R.*, Septem-

ber 1979). The author has reported that he could protect 75% animals from gastric ulceration induced by aspirin and indomethacin in female rats, with the help of estrogen and progesterone—the female sex hormone.

While working on a similar problem, we found that estrogen is ineffective while progesterone aggravates acute gastric ulceration induced by aspirin in rabbits.

It is therefore felt that the conclusion drawn by the author that female sex hormones, estrogen and progesterone, can save females from ulcers should be accepted with certain reservations.

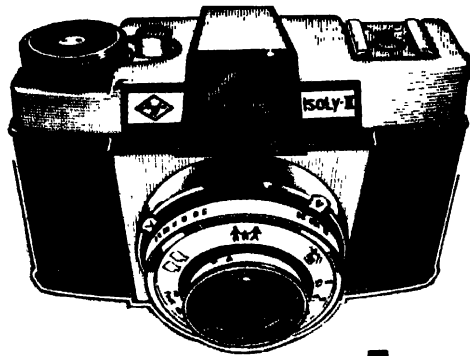
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Miraj Medical College, Miraj  
M. L. WAGHMARE  
Chemist  
Govt. Medical College  
Miraj (Maharashtra)

## Aerosols

Sir, **What are aerosols?** (*S.R.*, June 1979) by Pushpa Sharma and P. Bahadur was interesting. I would like to add a few points. The name aerosol was coined by Gibbs (1924). According to him, systems which are dispersed in air are called aerosols and were analogous to hydrosols in which the dispersing medium is water.

Aerosols can be divided into three types, i.e., solid, liquid and biological. Solid aerosols are solid in macroscopic sense and include dusts, smokes and fumes. Liquid aerosols consist of materials which in bulk are liquids at normal temperature and pressure. They may be inorganic or organic compounds. Examples : Hg, H<sub>2</sub>SO<sub>4</sub>, hexane, alcohols, aldehydes, benzene and derivatives. The smallest size of this category is the individual molecule. The third type, biological aerosols also consist

(Continued on page 135)  
SCIENCE REPORTER



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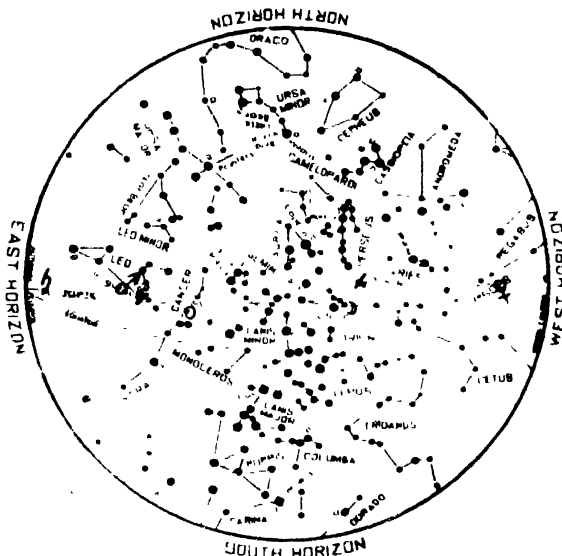
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# Planets and their positions

March 1980



MAGNITUDES  
1 0 -1 -2 -3 -4 -5  
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## PLANETS

VENUS ♀  
JUPITER ♃  
MARS ♂  
SATURN ♄

## MOON

○ FULL MOON 1ST  
☾ FIRST QUARTER 23RD

## The moon

**F**ULL moon on 2nd at 2.30 a.m. and again on 31st at 8.44 p.m. and new moon on 17th at 0-26 a.m. I.S.T. The moon passes about a degree south of Jupiter and four degrees south of Mars on the 1st, very close to Saturn in the early hours of 3rd, about three degrees south of Mercury on 15th, seven degrees south of Venus on 20th

and again four degrees south of Mars and about a degree south of Jupiter on 28th and half a degree south of Saturn on 30th.

The lunar crescent becomes first visible after the new moon day in the evening of 18th. In the western part of India the moon is likely to be visible one day earlier i.e. on March 17.

The moon is at apogee or farthest from the earth on 3rd and

again on 30th and at perigee or nearest to it on 17th.

The sun is at the Vernal Equinox on 20.

## The planets

**Mercury (Budha)** is too near the sun to be visible during the first half of the month. It is in inferior conjunction with the sun on 6th. Thereafter, it reappears as a morning star and rises about an hour before sunrise. It becomes direct on 19th. It is in Aquarius (*Kumbha*). Its visual magnitude varies from +1.8 to +0.6.

**Venus (Sukra)** an evening star, visible on the western horizon sets about three hours before local midnight during the month. It moves from Pisces (*Mina*) to Taurus (*Vrisha*) through Aries (*Mesha*). Its visual magnitude is about -3.8.

**Mars (Mangala)**, visible in the evening sky, sets about half an hour before sunrise during the first half of the month and about one and a half hours before it during the second half. It passes about 3° north of Jupiter around midnight of 2nd. It passes about 4° north of the star Regulus (*Magha*) in the very early hours of 18th. It is in Leo (*Simha*). Its visual magnitude varies from -1.0 to -0.3.

**Jupiter (Brihaspati)** visible in the evening sky, sets about half an hour before sunrise during the 1st half of the month and about one and a half hours before it during the second half. It is in Leo (*Simha*). Its visual magnitude is about -2.0.

**Saturn (Sani)** rises at about sunset and sets at about sunrise. It is in opposition to the sun on 14th. It moves from Virgo (*Kanya*) to Leo (*Simha*) by retrograde motion. Its visual magnitude is about +0.9.

(Source : Position Astronomy Centre, India Meteorological Department, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700 053.)



**A**N emulsion is a two phase system consisting of two immiscible liquids, one being finely dispersed in the other. The substance, which is present in smaller proportion, is usually known as dispersed phase, whereas the other constituting the bulk of emulsion is termed as continuous phase. Two types of emulsions 'water dispersed in oil' or 'oil dispersed in water' are commonly encountered. Can we form a stable emulsion? Thermodyna-

to coalesce. So to make an emulsion stable, the dispersed drops must be as small as possible. Many commonly used emulsions occur in foods, cosmetics, pharmaceuticals and many other formulations of industrial importance such as textile finishes, paper coatings, metal working, oil well drilling fluids, lubricants, etc.

Emulsions of water and petroleum oils have been tested extensively in countries like the U.S.A., Japan, the U. S. S. R., U.K., etc. They have

seventies, particularly after the oil crisis in 1973. Besides, strict regulations on pollutant emissions, e.g., oxides of nitrogen and particulates, in the stack gases, might have forced many companies that use fuel oils to look for newer methods which can possibly lower emissions to acceptable limits.

Black petroleum-water emulsion has largely been used as fuel oil, with the amount of water varying from oil to oil. White petroleum oils,

# EMULSION FUELS

## For Rapid Combustion

mically, the two liquid phases are highly unstable and usually an emulsifying force is required for emulsion formation. As soon as the dispersing force is removed, large-scale coalescence occurs in the dispersed phase, which reverts the emulsion back to its two phase system.

An emulsifying agent (also known as surfactant) is added to form the emulsion and/or to give it stability. Introduction of an emulsifying agent usually lowers the interfacial tension between the two liquid phases. Drop size is yet another important factor for stability; larger the drop size, greater is the tendency

varied applications—from boilers to motor vehicles, and it is now amply demonstrated that these emulsion fuels burn completely and more efficiently due to mini explosions in the combustion zone. A thorough mixing of fuel and air takes place due to these explosions resulting in dramatic reduction in soot formation and particulate solids in the flue gases.

Several emulsion combustion systems have been installed in the U. K. and the U.S.A., and the users have claimed savings in fuel and significant reduction in pollutants. Much of the work on emulsion fuels began in

such as gasoline and diesel oil, have also been tried extensively after emulsification. Their trials in motor vehicles showed 10 per cent increase in mileage and marked reduction in  $\text{NO}_x$  and smoke. Fuel oil emulsions containing different proportions of water have been tested in many industrial appliances such as boilers, furnaces, incinerators, etc. For making emulsion fuels, several techniques have been tried and these include high intensity mixing, sonic or ultrasonic irradiation. In sonic or ultrasonic methods, no emulsifying agent is used. In Japan, however, surfactants have been used

for emulsifying different fuel oils and water. Tests of pulverised coal-oil-water emulsions also indicate promising future for burning coal rather than converting it into liquid fuel. Combustion characteristics of coal-based emulsions are also similar to liquid fuels, and the combustion equipment, e.g., pumps, burners, etc., used for liquid fuels can be conveniently adapted to coal-based emulsions.

#### How an emulsion

When an emulsion drop containing small drops of water is heated by a direct flame, heat is initially transferred to the surrounding oil, which, in turn, transmits it to the water drops. Because of relatively higher boiling point, the oil drops remain as liquid while water begins to vapourise. Soon, the vapour inside the oil drop gets superheated and in escaping from the drop shatters the oil drop into many small fragments. Occasionally further shattering of the fragments also takes place. The fragments are usually of 1 to 2 micron size or less. Photomicrographic studies indicate that the fragmentation occurs rapidly (with an average velocity of 50 metres per second). As a result, the time taken for burning an emulsion drop is reduced to nearly half of what a pure oil drop takes.

A schematic arrangement of the combustion system for emulsion fuels is shown in Fig. 1. Controlled amounts of water and fuel oil are continuously drawn from their storage tanks and fed into an emulsifying chamber, where the two liquids are subjected to high intensity mixing. Vigorous agitation of high intensity mixing or ultrasonic irradiation produces large-scale cavitation bubbles and as they grow and implode they bring about internal stresses in the liquids. These disruptive forces disperse the water in oil

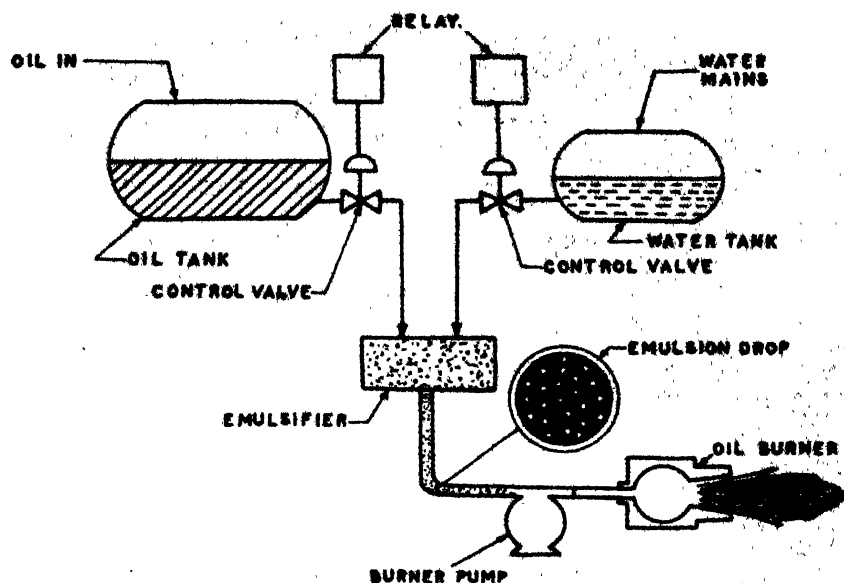


Fig. 1. Combustion system for emulsions

as fine droplets. The water-oil emulsion thus formed is continuously drawn by a pump and fed to the burner for combustion.

Vapourisation of water inside the oil drop usually occurs at superheat temperature (above the normal boiling point of water), and the degree of superheating usually depends on the purity of water used. Temperature often goes above 200°C-250°C, if water is pure. The wide difference of temperatures between the flame and water is responsible for high heat transfer rates, which are believed to result in superheated

boiling and/or spontaneous nucleation leading to explosion.

#### How efficient is burning

Pure oil drop burns in the usual way without disruption while the emulsion drop burns with 'explosions'. Each drop breaks violently into many minute oil drops much smaller in size than the pure oil drop (the size of the pure oil drop depends upon the type of device used for atomising the oil). The 'explosions' also bring about violent agitations within the combustion system,

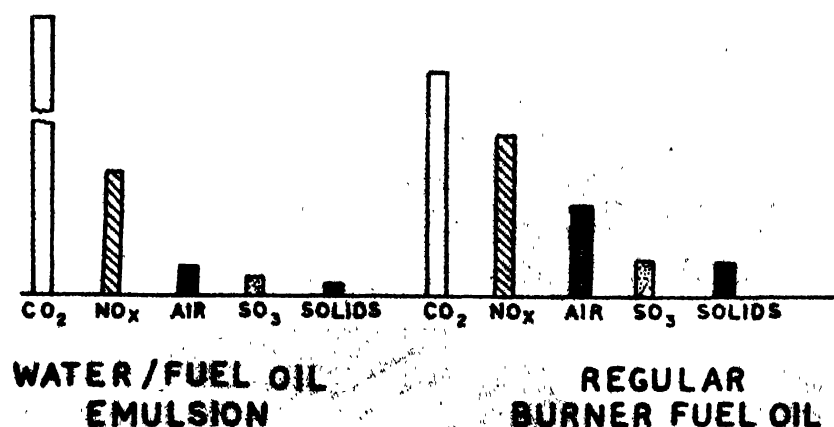


Fig. 2. Comparison of combustion products

**Table 1. Types of emulsion fuel studied**

<i>Sl. No.</i>	<i>Type of emulsion used</i>	<i>Method employed</i>	<i>Benefits</i>
1.	5% water in gasoline for carburatted engines	Ultrasonic emulsification under a pressure of 5-6 kg/cm <sup>2</sup>	(a) 3%-4% increase in effective power of the engine.
2.	1% to 20% water in petroleum fuel	Suitable surfactant used	(b) 5%-6% decrease in NO <sub>x</sub> in exhaust. Formation of CO, hydrocarbons and NO <sub>x</sub> minimised.
3.	1% to 80% water in petroleum for internal combustion engines	Suitable surfactant used	(a) Soot, CO, NO <sub>x</sub> and hydrocarbons reduced.
4.	Emulsions containing water and fuel oil, in industrial scale	—	(b) Engine performance improved (a) Lowering of excess air
5.	Water-liquid fuel emulsion used in blast furnace	Blowing steam through a porous material into a stream of liquid fuel	(b) Reduction of NO <sub>x</sub> and fly ash
6.	2%-40% water in fuel oils for electric power plants	By single or multistage mixing with gear or rotary pumps	(c) Reduces SO <sub>2</sub> conversion to SO <sub>3</sub> (d) As efficient as fuel oil.
7.	Less than or equal to 30% water with diesel fuel investigated in pilot plant for heat engines	Synthetic nonionic surfactants	—
8.	10 to 74 volume parts of water and 26-90 parts fuel oil	Agitation at 500 RPM without emulsifying agent.	Less smoke and less NO <sub>x</sub> in exhaust
9.	Lighter oil and fuel oil emulsified with water	—	Less NO <sub>x</sub> (40% to 50% reduction)
10.	5% to 50% water burned in two stage combustion system.	—	Marked reductions in the emissions of soot and NO <sub>x</sub>
11.	1% to 74% water in heavy oil emulsions	Less than 5% water soluble surfactant	Stack gases contain reduced amounts of NO <sub>x</sub> , soot and smoke.
12.	20%, 40% water in fuel oils emulsions to run steam engines.	Without the use of emulsifier using homogenisation technique.	—
13.	20% water petroleum fuel oil emulsion	Nonionic surfactant namely 1.3% Ca alkyl benzene sulphonate injected.	30% reduction in dust and NO <sub>x</sub>
14.	15% water and petroleum fuel oil emulsion	1.2% emulsifying agent	Reduced NO <sub>x</sub> and dust by nearly 40%-50%
15.	Emulsion containing 7.6% water, 4.8% sulphonated oil	2.8% emulsifying agent	(a) Fuel consumption decreased by 16% (b) Increase in heat transfer and energy output. (c) Reduced pollution Reduction in soot
16.	Water (9%-23%), pulverised coal—0%-2% powdered dolomite—0%-2%, fuel oil—77% to 90%	—	94% reduction in NO <sub>x</sub>
17.	40% water emulsified with diesel oil containing 1.5% sulphur	—	—
18.	Emulsion containing 20% water in fuel oil studied in a batch type of furnace 70 cm × 70 cm × 70 cm.	Surfactant Poly (oxyethylene mono (nonyl phenyl) ether (1% of total emulsion)	(a) Combustion efficiency increased (b) Pollutant gases decreased (c) 8% saving in fuel oil.
19.	12.5% water, powdered coal, MgO and oil emulsion	—	(a) 17%-86% reduction in NO <sub>x</sub> (b) Reduction of S oxides by 40%-50% (c) The soot formation was kept minimum.
20.	10%-15% water in oil emulsions used in small boiler capacity 300 kg/hr.	Mechanical shock stirring	(a) 30%-50% NO <sub>x</sub> lowered (b) Saving of oil by 20%

the result of which is that more collisions between carbon, hydrogen and oxygen atoms take place accelerating the combustion. Besides, the superheated steam coming out of the drop mechanically removes the inhibiting layers of carbon dioxide, oxides of nitrogen, water and nitrogen from the vicinity of oil surface. A good example of this action is a Blacksmith's forge, where large quantities of excess air are blasted across the burning coal. Yet, the coal gets brighter and hotter. Normally one expects that such a large quantity of air will cool the burning coal, but instead the burning is much better. This is because of continuous removal of inhibiting layers of carbon dioxide, water and nitrogen by blasts of air.

During combustion process many chemical changes such as dissociation and association take place. Water, for example, dissociates into hydrogen and oxygen, which may associate again to form hydroxyl radicals. Besides, the temperature of the combustion zone promotes a series of photochemical reactions which result in the formation of many more compounds; some may be even more combustible. Combustion of pure oil usually results in formation of gaseous products like carbon dioxide ( $\text{CO}_2$ ), oxides of nitrogen ( $\text{NO}_x$ ), carbon monoxide ( $\text{CO}$ ), sulphur trioxide ( $\text{SO}_3$ ), etc. In addition, excess air (used for combustion) and unburnt carbon are present in the exit gases. Fig. 2 indicates graphically the different constituents present in the exit gases obtained from burning of ordinary burner fuel oil and emulsion fuel. It can be seen that the presence of such large quantities of  $\text{CO}_2$  with fewer solids and less air clearly indicates that the combustion of emulsion fuel is complete.

Emulsion fuels require less excess air for combustion when compared to pure oil, as part of the fuel is replaced by water. Superheated steam

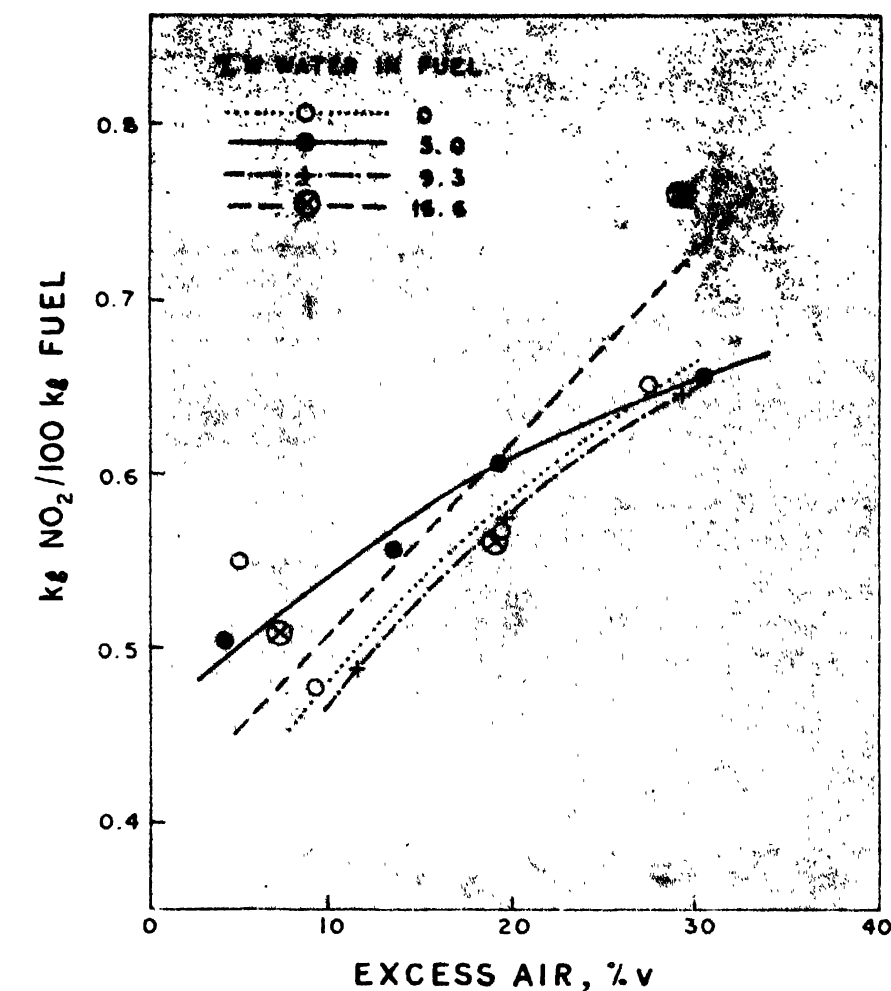


Fig. 3. Extent of  $\text{NO}_2$  formation in relation to excess air

coming from the shattering emulsion drops depletes the gases like oxygen and nitrogen from the combustion zone. Superheated steam is a better medium for heat transfer compared to both nitrogen and oxygen. So, the heat transfer rates greatly improve.

Studies on the combustion of 1000 micron water-oil emulsion drop and pure oil drop of the same size show that the size of the flame is considerably improved by 'miniexplosions' during the combustion of emulsion drop.

To save at least 4000 gallons of fuel oil per week, Adelphi University, U. S. A. is using ultrasonic combustion system which feeds a mixture of

75% oil and 25% water to campus oil burners. It reduces the oil consumption by one fourth without any loss of efficiency and dramatically reduces pollutants emitted from the combustion system. In a pilot plant installation at the Bayville Intermediate School fuel consumption was reduced by about 22%. Emissions from the heating systems were also considerably reduced. Fuel mileage increased by 10% depending upon the model of the cars when a mixture of 18% water and 82% gasoline was used as fuel.

#### Reduction of pollutants

During the combustion of fuel oils, many pollutants like oxides

## What is combustion

**C**OMBUSTION is a chemical process in which carbon atoms burn to form carbon dioxide ( $\text{CO}_2$ ) or carbon monoxide ( $\text{CO}$ ), and hydrogen burns to form water. Petroleum fuels are large complex molecules consisting of carbon and hydrogen atoms. During the combustion process, a series of collisions occur between carbon, hydrogen and oxygen atoms resulting in the formation of products like  $\text{CO}_2$ ,  $\text{CO}$  and water. Air is the commonly used source for oxygen supply and thus each part of the oxygen entering the combustion system brings four parts of nitrogen. These nitrogen passengers do not take part in the combustion process; instead, they carry away some heat from the process.

Combustion carries with it the seeds of its own destruction. For instance, both carbon dioxide and water are the most commonly used

materials for putting off fire. Large quantities of nitrogen also enter the system (along with the air). All these substances tend to retard the combustion process by forming inhibiting layers between burning hydrocarbon and oxygen. It is therefore necessary to remove these inhibiting layers as soon as they are formed in order to sustain combustion. This is the reason why air is used in much larger quantities than is required. In addition, fine oil spray also exposes more oil surface to burn with oxygen. Another important factor (on which combustion largely depends) is the correct mixing of fuel and air. The process of mixing is complex, and even though we achieve correct mixing in a cold combustion model, it is difficult to attain the same degree of mixing in actual combustion systems.

K.L.N.

K.M.R.

Particulates are also effectively controlled by the use of water as an emulsion. The exact mechanism is not clearly understood so far. However, reduction of particulate emission can be attributed to the chemical effects of hydroxyl radicals of water or to the disruption of oil droplets by the evaporation of water entrapped in the emulsion drop or the effect of both.

Several commercial combustion systems are available for emulsion fuels. Most of them have either a mechanical, sonic or ultrasonic probe for emulsifying water and oil.

### Emulsion technique for coal

J. Doohar of the Adelphi University Centre for Energy Studies, U.S.A., investigated emulsions of pulverised coal-oil-water. The results indicate promising future for burning coal. The fuel contained 50% pulverised coal, 10% water and 40% oil. The fuel remains stable for many months, which is a desirable property.

Emulsions containing 3 parts of pulverised coal ( $100\mu$  or less), one part of fuel oil and one part of water had properties similar to a medium fuel oil. However, the burner assembly had to be modified for burning this fuel.

of nitrogen ( $\text{NO}_x$ ) and particulates are produced. They are hazardous to human health and need to be controlled. In India, this problem does not appear to have attracted the attention of environmental experts so far. However, in highly industrialized countries like the U.S.A., U.K., Japan, etc., there are strict regulations on stack gas emissions, particularly of  $\text{NO}_x$  and particulates.

Atmospheric nitrogen and nitrogen content of the fuel oils are the two main sources for the formation of nitrogen oxides ( $\text{NO}_x$ ). The only method, which has been amply demonstrated to reduce markedly both  $\text{NO}_x$  and particulates, is the use of water in combustion system either in the form of an emulsion of water in oil or as fine water spray or by injection as steam. The presence of water lowers the flame temperature by nearly 10%-20% (which is below

the dissociation temperature of air) so that the conditions for the formation of thermal nitrogen are eliminated. The use of 5% water in gasoline reduces  $\text{NO}_x$  formation by 5%-6% in carburetted engines and 15% water in fuel reduces the  $\text{NO}_x$  by 40%-50%.

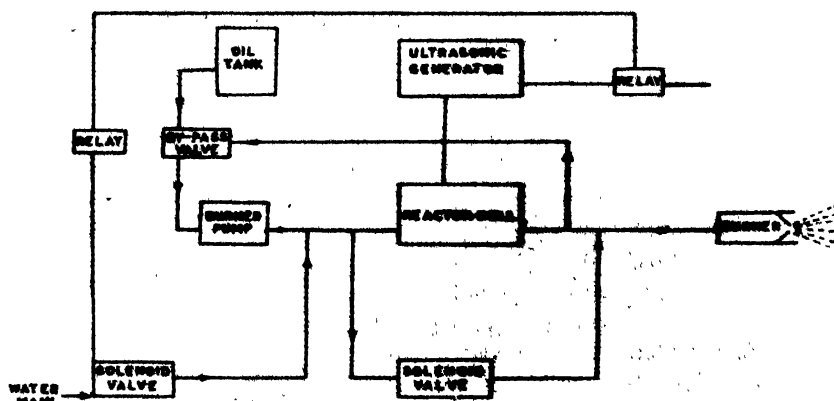


Fig. 4. Flow chart of Cottrell's ultrasonic combustion system

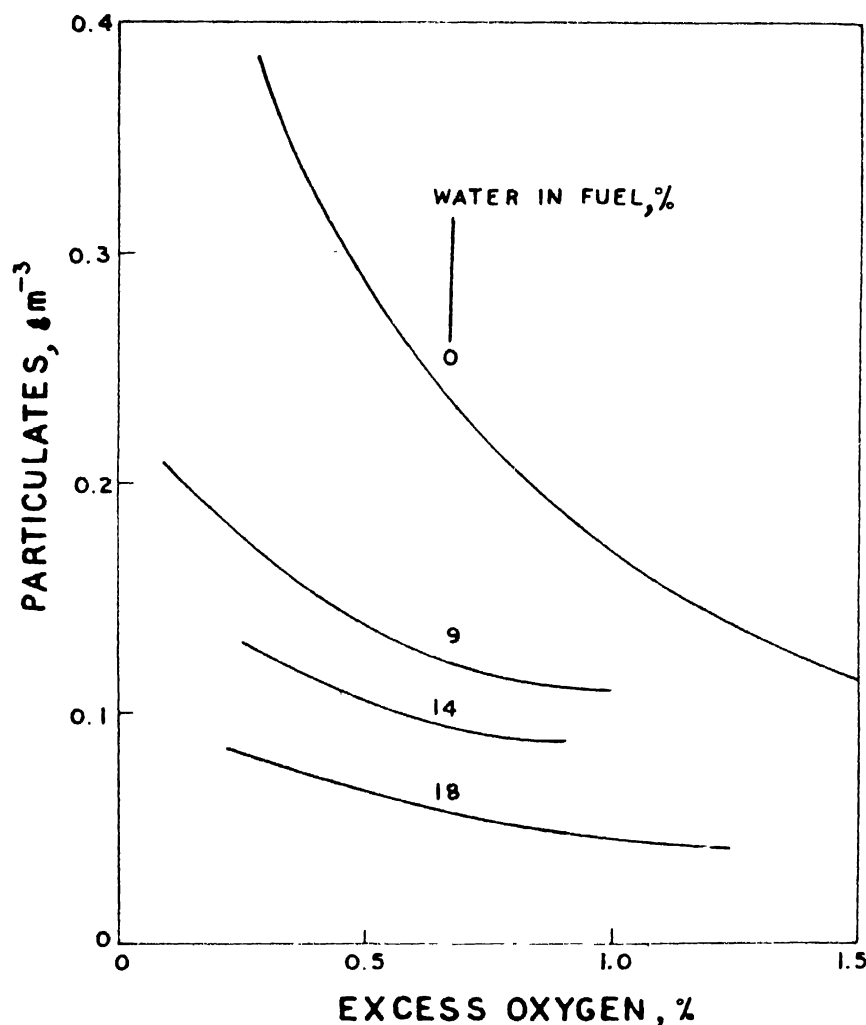


Fig. 5. Extent of particulate formation with water-fuel oil emulsions

#### Future for emulsion fuels

It is now an established fact that the use of water markedly reduces particulates during the burning of liquid fuels and keeps the levels of nitrogen oxides low. It has been observed that if the dispersion of water in oil is uniform, only a small

quantity is required and it need not exceed 30% of the emulsion. Any increase above the limit is likely to impair the efficiency. For making water-oil emulsions, any high intensity mixing technique can be used, and to achieve stability, surfactants can also be used. Among the emulsifying techniques ultrasound seems to

have an edge over the others. However, the cost factors may come in the way of its acceptability. There are, however, still several problems that come in the application of emulsification technique and so need further research, viz., (i) Importance of water quality and effect of contaminants/salts on the combustion system unit, (ii) Reliability of the equipment used to produce emulsions, and (iii) Influence of emulsion technique on the formation of fine particles/smoke due to shattering of oil droplets

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#### Corrigendum

Read author line for article *About DNA that is silent*, (S.R., Jan., 1980) as: "Dr. Bansal is associated with Chromosome Research Centre of the Deptt. of Botany, University College of Science, Calcutta University, Calcutta-700019."

**T**HE decision about the suitability of a person for promotion to a higher class, award of degree for a definite course and appointment in a particular job involves his evaluation through an examination or an interview. These are essentially the processes or acts of testing or trying an individual as regards his intellectual development, knowledge, fitness, calibre and aptitude. Accordingly, written tests, viva-voce, discussions, etc., constitute various methods of assessing and hence grading the candidates.

From physics point of view, a person subjected to such an evaluation can be treated as a system (of course, composite in nature) or an

object under study, whereas his knowledge, presence of mind, wit, etc. are the variables which are being determined. Therefore, it should be possible to analyze the process of assessment in the framework of physics and the present article is the outcome of an effort in this direction. It turns out that the concepts of physics can be exploited in an interesting manner to reach at meaningful conclusions.

#### **Physical measurements : standard scales**

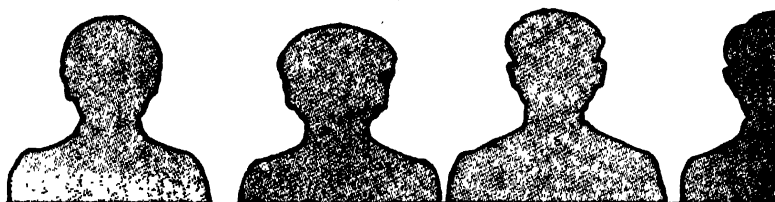
The first step in the measurement of any quantity is to define an appropriate scale which can be used as a unit for expressing the findings. For example, while determining a distance, proper unit like Angstrom, metre, kilometre or light-year is chosen and then the length involved is written as a number times the unit. In the case of written tests few questions are asked in a paper; these are allotted some marks and the can-

didates are gauged according to their total score. Similarly, in an interview the evaluating agency defines some norms and the candidates are assessed with respect to those. As in the case of measurement of physical quantities, the proper choice of questions and norms (the scale) is very important so that the results are well presentable.

Once the scale has been decided, one comes to the actual act of measurement. Unlike the determination of metric length and temperature, one

pondence between an observable of the system under study and another observable of the measuring device or probe. The difference between the initial and final conditions of the probe can be interpreted to yield information about the system. For example, if we want to study the position and velocity of a moving object, we can use light photons as probes and the resulting reflection pattern can be analyzed to give parameters defining the movement of that body. Similarly, the positions of

## **THE PHYSICS OF**



## **CANDIDATE EVALUATION**

does not have to establish a physical contact between the object and measuring device in checking calibre, knowledge, etc. Instead the situation is relatively closer to the measurements on inaccessible systems such as atoms, nuclei, electrons, etc. This involves development of some connection between a phenomenon pertaining to the system and that leading to our realization of this so that the state of the system under investigation is completely known. Now measurement of any physical quantity for a system requires its study with probes like photons, neutrons, electrons, etc. The probes interact with the system and give rise to a response signal which is decoded into desired type of information. Thus the essential requisite for measurement is one-to-one corres-

atoms in crystals are obtained by diffraction of X-rays or neutrons from the planes of the atoms.

The main requirement of precise and accurate measurement is that the interaction between the probe and the system should be so weak that the disturbance caused in the latter can be neglected. Otherwise, the results obtained will be those pertaining to the perturbed system and will not be true representative of the original system. Rather they will fall in the category of subjective idealism from philosophy point of view. This demands that the probe should be chosen carefully so that it does not render the system unstable and also that the system must not be very sensitive. Preferably, the system should continue to be near its equilibrium.

## No embarrassment or provoking

Applying the above principles to our system, i.e., the candidate, we see that the questions (written or oral) are the probes and answers to these constitute the response which has to be properly interpreted by the experts for correct evaluation. Obviously, the assessment of the candidates can be true and more reliable if the questions asked are such that candidates remain normal. For this to be so, not only proper quality of questions is significant but continuity of candidate's mental equilibrium is also important. To be explicit, the examiners should not ask very embarrassing questions and should avoid provoking the candidates; rather their style of putting these questions should be so modest and affectionate that the candidates do not lose balance. A further implication of this aspect is that the candidates should develop their personality to such an extent that they maintain equilibrium under all conditions. If we subject these conjectures to tests, we find that a particular person does better if the examiner remains co-operative and cordial whereas his performance becomes depressing if the attitude of the examiner is hostile and repulsive. Similarly, a sensitive and over cautious candidate becomes nervous (i.e., loses equilibrium) and his performance is affected, while another person may do better if he remains unnerved even though his knowledge is relatively poor.

## Extrapolating Heisenberg's Principle of Indeterminacy

Next, the evaluation of the level of a person, i.e., his calibre and quickness in answering the questions is like simultaneous measurement of two physical parameters. According to Heisenberg's principle of indeterminacy, the so-called first golden rule of quantum mechanics, the product

**Well known concepts of physics have been used to discuss the process of evaluation of the candidates in examinations and interviews. The conclusions arrived at are amazingly realistic and convincing**

of the errors (uncertainties) in simultaneous determination of a pair of canonically conjugated coordinates, like position and momentum, must be at least of the order of Planck's constant of action ( $h$ ). Thus if we measure a quantity very accurately, we do so at the cost of precision in its conjugate quantity. For example, suppose we are interested in finding the state (position and momentum) of moving electrons at a particular time. That is, if we want to know their distribution in the phase space, we shall use photons as probes to study the system. In order to find the positions of the electrons very accurately, we shall need photons of very small wavelength (therefore, of very high energy), say x-rays, so that the resulting diffraction pattern is well resolved. But when high energy photons interact (collide) with electrons, they exchange momentum and the latter will recoil. Thus the momentum of the electrons will be changed and we shall not be able to get correct information about this aspect. On the other hand, if we employ photons of high wavelength (low energy), the disturbance caused to the electron system will be less which will give velocity precisely, but the diffraction pattern giving position will be hazy leading to more uncertainty in position.

To extend the above argument to our system, we can label the calibre as position and quickness in reply as momentum defining the mental state of the candidates. Accordingly, the question of their evaluation is reduced to their arrangement in the phase space of knowledge and minimum uncertainty in this will be of the order of some constant of action. Without bothering about the

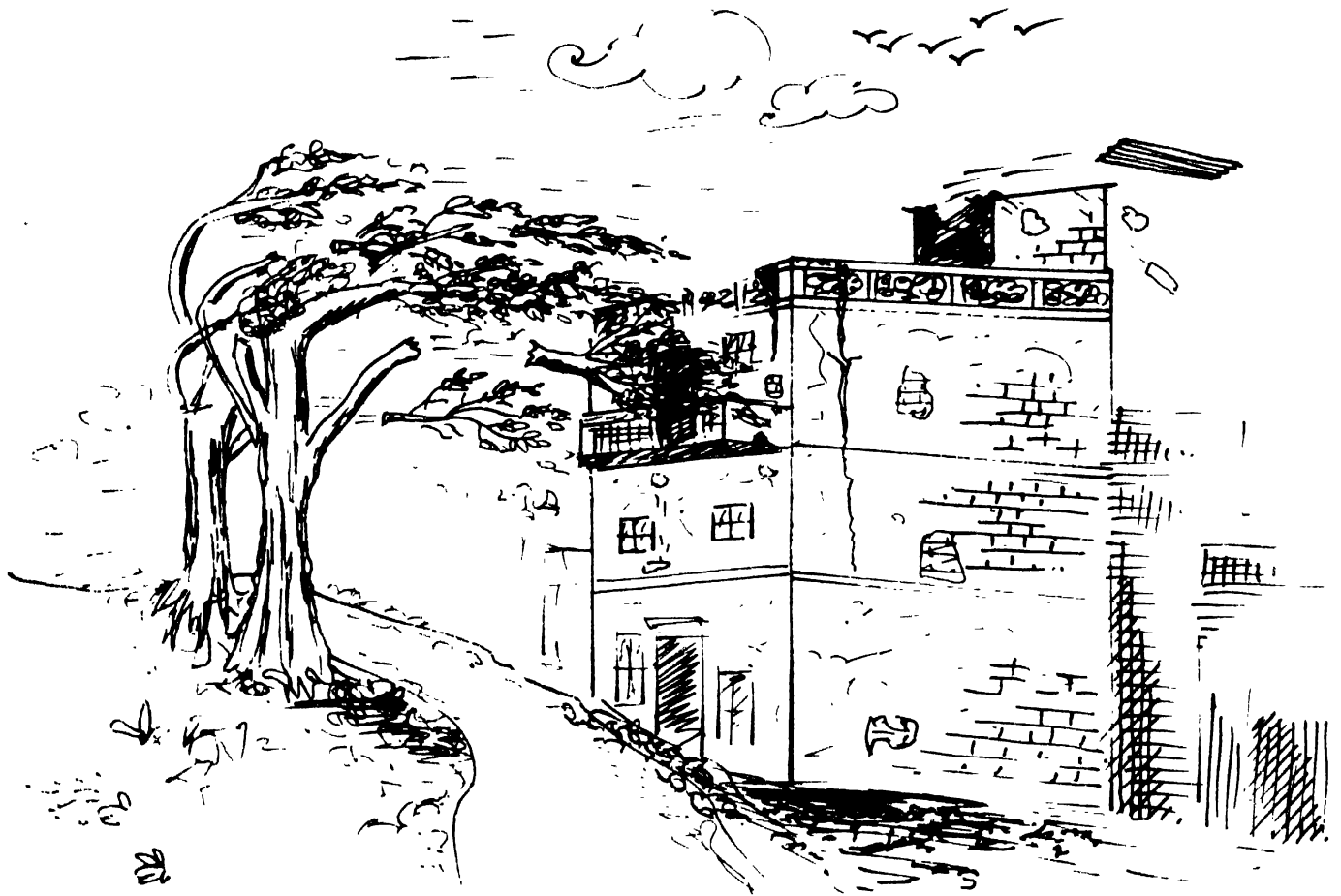
magnitude of this constant, we see that if the probes (questions) are of high energy (difficult) then the examiner can determine the position (calibre) of the candidates accurately only at the cost of proper information about momentum (quickness in response, which depends on the presence of mind) and vice versa. However, with moderate probes (questions) one can know both the quantities reasonably accurately. Therefore, the examiners should ask only such questions from which they can assess the calibre as well as presence of mind of a candidate with desirable accuracy.

## Sufficient time for proper check up

While talking about the Heisenberg's Principle, we know that it also applies to measurement of energy and time at a fixed point  $X$  in two-dimensional space-time. In that case its statement reads; if we carry out an observation within a time  $\Delta t$  and use it to determine the energy of the system at the same point  $X$ , then the uncertainty  $\Delta E$  in energy would be such that the product  $\Delta E \cdot \Delta t$  is always greater than the Planck's constant. Once again we can use this concept in our problem if we take the knowledge of a person as energy content of the system. If the system (candidate) is perceived (questioned) for a time  $\Delta t$ , then the uncertainty in the information about his knowledge will be inversely proportional to  $\Delta t$ . Consequently, the evaluation will be more reliable if it is carried out for a longer interval (larger  $\Delta t$  implies smaller  $\Delta E$ ) and hence a candidate should be questioned for sufficient time so that his knowledge can be checked properly.

*(Continued on page 131)*





# WIND EFFECTS ON STRUCTURES

N. SUBRAMANIAN

R. RADHAKRISHNAN

*"If a builder builds a house that is not firmly constructed and it collapses and causes the death of the owner, that builder shall be put to death."*

The Laws of Hammurabi, King of Babylonia, 2200 BC

**W**ITH the advancement in civilization, the builder in the modern

world has the challenging task of building structures of new shapes and new heights soaring into the sky and plunging into the sea. In the last twenty years, buildings more than 30 storeys high have come up in many parts of the world. In the metropolitan cities of our country many 15 to 20 storeyed buildings

have been constructed and taller buildings are in the offing. The new shapes of structures and heights of buildings have instilled a greater awakening among engineers for dynamic design of structures.

## How buildings vibrate

Change of temperature and hu-

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midity within materials set up potential differences and static electricity flow and cause bodies to vibrate. External impacts and forces such as moving vehicles, natural forces like wind, sea-waves, rain and earthquake all cause bodies to vibrate. Sensitive pickups will indicate that the ground which, to human senses appears to be stationary, is constantly vibrating at its natural frequency—a phenomenon known as microtremors. Buildings and their floor systems also constantly vibrate. Static behaviour of buildings for purpose of stress analysis is only an idealisation which is good for practical purposes where there are only microtremors and no heavy live loads. But when structures are subjected to dynamic loads such as due to wind, earthquakes, tsunamis and vibrating machine loads, the idealisation of a static equivalent is a crude approximation and dynamic design methods are imperative.

Before analysing any structure for its dynamic behaviour, the causes like the wind, earthquakes, etc., which make the structure vibrate should be studied in detail. In our earlier article (*What are earthquakes?* S R., December 1977) we have studied about earthquakes. Although a large amount of literature on the wind effects on buildings are available now, there are not many comprehensive books dealing with this subject. Hence an attempt has been made in this article to discuss briefly the causes and effects of wind on structures.

### The wind

Wind is one of many natural phenomena over which man has no control. Large-scale storms, thunderstorms and tornadoes produce high wind speeds and, in the case of tornadoes, high local pressure gradients which will exert large pressures on any building enveloped by them. Too often these pressures are sufficient to cause substantial damage to struc-

**Loads imposed on structures by wind act horizontally and cannot normally be resisted by the main structural system designed to carry gravitational loads acting vertically downwards**

tures, particularly to their roofs. Since it is impossible to control the wind, designers aim to make their buildings resistant to wind damage.

### Causes of air movement

Air is seldom quiet but flows, sometimes with great violence, under the influence of forces generated by heat from the sun, and the centrifugal forces resulting from the earth's rotation. The wind may be defined as the motion of air caused by gravity, by deflective forces due to earth's rotation, and by centrifugal forces due to the curvature of the wind path. These forces are opposed by others arising from friction and viscosity. The air never flows with a perfectly smooth and streamline motion, but always with horizontal and vertical fluctuations which, when sudden and relatively brief, are called gusts. Due to the rotation of earth, each air particle in the atmosphere has an angular momentum, which is directed from west to east. Regions near North and South poles have very disturbed weather, with many depressions and anticyclones. These depressions are caused by the meeting of warm and cold streams of air. An idealized depression has a belt of rain or snow surrounding the warm air. In a depression, the cold air will force itself into a less dense warm air. Thus, the centre will be at low pressure and the outer winds will be at higher pressure. (The maximum pressure differential in a depression is of the order of 0.05 atmosphere or 50 millibars). Thus, in common with all meteorological phenomena, the wind also derives energy from the sun.

At heights between 8000 metres and 13000 metres a tubular current of air may form, with a very high

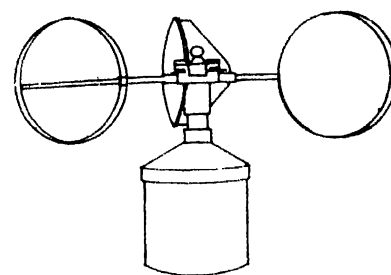


Fig. 1. Three cup anemometer generator. Internal cup diameter 12.5 cm

wind speed, called a jet stream. Another high speed wind called tornado is characterized by a vertical spiral of very high speed wind with a relatively short life.

Hurricanes or typhoons are tropical depressions, smaller in area but more severe than the depression of temperature zones. They originate over warm oceans and derive energy from the latent heat of evaporation of water sucked into low pressure centre. Their paths are entirely random and are characterised by high tidal surges. Tornadoes and hurricanes are cyclonic storms, but fortunately most cyclones are neither tornadoes nor hurricanes.

Eddies are created in air when they meet a sharp discontinuity on the earth's surface, such as a building, tree or mountain. Eddies travel for long distances, and when superimposed on the mean air-flow, give rise to variable winds. When the wind reaches a peak, it is called a gust, and at its minimum it is called a lull.

### Wind forecasting

There is no way of forecasting the variations of wind, even after many years of records. Certain tendencies, like the change of direction on the onset of a gust, the quick rise in wind

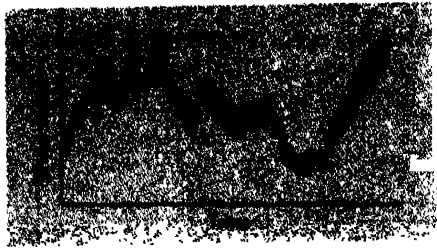


Fig. 2. Continuous Anemogram record

speed, etc., have been observed. It can be said that the wind variation over a short period (about 1 hour) are entirely random about the mean spaced over that period. The random pattern remains same at all times for any wind measurement site as long as the conditions remain same. This fact is very important since future maximum, minimum and wind speeds can be forecast from short term records by using probability analysis.

### Wind measurements

The wind force or pressure on a structure is taken to be proportional to the square of the wind velocity. Hence precise measurements should be done in order to minimize the error especially for high wind velocities. Devenport of National Research Council of Canada, Ottawa showed that the atmospheric stability and surface roughness, affect the variations of velocity with height.

Since vertical components of atmospheric motion are relatively small, especially near the surface of the earth, the term "wind" is commonly considered to denote the horizontal component of the wind. Hence wind velocities are measured in a horizontal plane, though vertical gust component exists. The term velocity indicates direction and speed; but not all the instruments measure both. Wind direction is measured in a clockwise direction from north, either in  $360^\circ$ ,  $45^\circ$ ,  $22\frac{1}{2}^\circ$  or  $11\frac{1}{2}^\circ$ . Wind speed is measured usually in miles per hour or kilometers per hour.

The earliest wind speed indicators were plates which were hung on a horizontal axis, and were maintained on a cross-wind direction and were not suitable for continuous recording. Hence presently wind velocities are assessed by anemometers which are installed at meteorological observatories at heights generally varying from 10 m to 30 m. Many types of anemometers are in use today, and the four main classes of anemometers are : (1) Pressure anemometer, (2) Rotation anemometer, (3) Gust-measuring anemometer, and (4) Cup anemometer. Fig. 1 shows the three-cup anemometer generator which is used in India. When wind speed patterns in fractions of seconds are required to be recorded graphically the ERA gust anemometer is used.

The anemometers usually record wind speed on an anemograph. These records are either continuous or stepped depending on whether the anemometer drives a continuously measuring transducer or an integrating counter. These data are presented monthly and yearly and include :

- (1) the height of anemometer above the mean sea-level;
- (2) the height of anemometer above ground;
- (3) the effective height of anemometer;
- (4) the distribution of mean hourly wind speeds;
- (5) the maximum mean-hourly wind speed and duration; and
- (6) the maximum gust speed and direction.

Fig. 2 shows the anemograph of a continuous recording anemometer.

### Wind pressure

A steady wind with velocity  $V$  exerts a dynamic pressure on an opposing surface equal to  $C_d \frac{1}{2} \sigma V^2$ ; where  $C_d$  is the coefficient of drag for steady flow and  $\sigma$  is the mass of air per unit volume. The coefficient

of drag varies with the shape of the structure.

### Wind damage and effect on structures

There are numerous examples of building failures due to wind. Many of these have occurred during erection, which indicates the carelessness on the part of engineers with regard to the effects of wind. Experimental efforts to determine the wind effects on structures dates back to Galileo (1655) and Newton (1687) and are continuing at the present time. By measuring the resistance of a sphere swung at the end of a pendulum, in air and water, Newton arrived at the conclusion that wind force is proportional to the square of the velocity of the wind. The wind tunnel provides a facility for measuring the forces resulting from the wind and advances in the field of fluid mechanics permit a rational interpretation of wind-tunnel tests.

The prodigious feats in bridge building in Europe and America, in early 19th century were not without disasters. The most consequential was the failure in 1879 of the bridge across the Firth of Tay, the then longest bridge in the world with 84 truss spans. This bridge designed by Sir Thomas Bouch was blown down by wind, with the loss of 75 lives. No allowance was made for wind in the design of the bridge and the specifications at that time did not call for any such allowance. The work began at that time by Bouch on the design for a railway suspension bridge across the Firth of Forth was taken over by Benjamin Baker.

Baker conducted experiments on different sizes of wind gauge boards in order to overhaul the evaluation of wind loads and came to the conclusion that the average force on a large surface was less than that on a small surface. He designed the Firth of Forth bridge for an equivalent wind pressure of  $4 \text{ kg/cm}^2$  after comparing

the shape factor for a flat plate with that of a model of his bridge truss suspended in wind stream.

Gustaf Eiffel constructed the 300m high Eiffel Tower in 1899 to mark the occasion of the Paris Exhibition. In its design he adopted a wind pressure of 200 kg/m at the base, linearly increasing to 400 kg/m at the top. He also conducted experiments on a model of Eiffel Tower. Wind tunnel tests were also started with Eiffel, on flat plates.

The collapse of Tacoma Narrows bridge (Tacoma, Washington) in 1940 and the failure of Ferry bridge cooling towers (United Kingdom) in 1965 due to wind induced oscillations provided the impetus for much research which has contributed to the knowledge of both aerodynamics and aerostatic forces. The Tacoma Narrows bridge after being in operation for about a year, was completely wrecked by a moderate wind of velocity 57 km per hour. In the years

## The Beaufort Scale

LIKE the Modified Mercalli Scale for earthquakes, there exists a scale for estimating wind speeds and their effects. It has been found that this scale gives results with surprising accuracy. This scale is given below :

No.	Beaufort description	Speed (m p h)	Land effect
0	Calm	under 1	Smoke rises straight up
1	Light air	1—3	Direction shown by smoke dirf
2	Light breeze	4—7	Wind felt on face; leaves rustle
3	Gentle breeze	8—12	Leaves in constant motion; wind extends light flag
4	Moderate breeze	13—18	Raises dust and loose paper; small branches move
5	Fresh breeze	19—24	Small trees in leaf begin to sway
6	Strong breeze	25—31	Large branches in motion. whistling of telegraph wires
7	Moderate gale	32—38	Whole tree in motion; difficulty in walking
8	Fresh gale	39—46	Breaks twigs off trees
9	Strong gale	47—54	Some damage to vegetation and structures
10	Whole gale	55—63	Trees uprooted; considerable damage
11	Storm	64—75	Widespread damage
12	Hurricane, Cyclone and Typhoon	over 75	Total damage



Fig. 3. Girder-stiffened suspension bridge; (a) Formation of Karman vortices, (b) Vertical modes, (c) Torsional modes

that followed, elaborate wind tunnel experiments were conducted at the University of Washington which revealed that the cause of failure was a Karman-Vortex trial on the I-shaped bridge section. The eddy frequency of the bridge deck on its suspension cables resulting in resonance and consequent failure (Fig. 3).

### Dynamic wind effects

Though enormous data is available in the static effects of wind, the data on dynamic effects of wind is still in its infancy. Dynamic wind effects on structures fall under two major categories, viz., "forced vibration" and "self excited vibration". The more common and important type of forced vibration on buildings is the "inline gust excitation" in the direction of the wind and the second type is the Karman-Vortex excitation

in the direction perpendicular to the wind.

Self-excited vibrations consist of galloping, torsional flutter and coupled flutter. Though transmission lines are subjected to galloping, buildings are not known to be sensitive to these modes of vibrations. Though the vortex shedding is well understood, the spectrum method, by which stresses due to buffeting by gusts are estimated, employs a crude mathematical model of what is a very complex system. The results given by it probably constitute not more than a very rough approximation to the real situation. Research in the area is, therefore, still intensive and no really accurate and comprehensive code of practice has yet been produced.

### Wind loading on buildings

Any structure built on earth's surface must be capable of withstand-

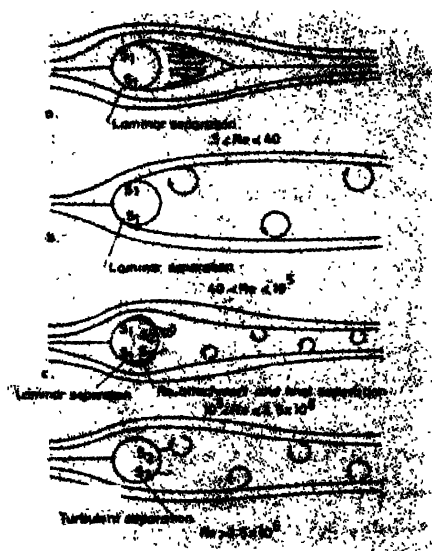


Fig. 4. Vortex structure to leeward of a cylinder at different Reynolds numbers

ing the loads imposed on it by the weather. The wind constitutes one of the major forms of loadings, since even moderate winds are capable of imposing high forces on structures. Hence, building codes usually incorporate lengthy sections devoted specifically to those aspects of the design and construction concerned with wind load. The loads imposed on structures by wind usually act horizontally, and they cannot nor-

## Van Karman Vortex Excitation

WHEN a structure vibrates, without an external exciting force continuing to act on it, it is in free vibration and the frequency of vibration is the natural frequency of the structure.

When a real fluid flow consisting of streamlines at very low speeds, flows past a rigid circular cylinder, higher speed vortices are formed in the wake. The flow pattern depends on the value of Reynold's number  $R = Vd/\nu$ , where  $V$  is the fluid velocity,  $d$  is the diameter of cylinder and  $\nu$  is the kinematic viscosity of the fluid. For a wide range of values of  $R$ , the vortices are shed from the cylinder in a regular pattern, alternately clockwise and anticlockwise from either side, as shown in Fig. 4. This pattern is known as Von Kármán Vortex Street (named after Theodore Von Kármán of California Institute of Technology, U.S.A.). The Vortex

shedding on alternative sides of the cylinder causes a harmonic force on the cylinder, acting in the direction transverse to the flow. Resonance occurs when the structural frequency coincides with the shedding frequency of the vortices. Practical examples of vibration of structures excited by Karman Vortices include: (a) electrical power lines, (b) submarine periscopes, (c) tall stacks, and (d) bridges.

The suppression of vortex excited oscillation by aerodynamic means can be achieved either by weakening the intensity of the vortices or by disrupting the periodicity of their formation. Perforated circular shrouds, helical strakes and longitudinally placed slats have been used in circular, cylindrical members as effective vibration suppressors at subcritical and transitional values of Reynold's numbers.

mally be resisted by the main structural system which is designed to carry the gravitational loads acting vertically downwards. Hence two structural systems, one to resist ver-

tical loads and another to resist horizontal loads due to wind, are required to ensure the stability of a building.

The calculation of the load which wind exerts on a structure involves two branches of science, meteorology and aerodynamics. For its calculation, the maximum wind speed which will occur in the vicinity of the structure during its life time and the directions of the pressures produced on the surface have to be determined. Fairly comprehensive data are available at present on the static effects of wind and on the distribution of pressure over the surface of buildings.

To provide stability against wind loads, a few more structural elements are necessary in addition to those required to resist gravitational loads. These elements are known as bracings, and because they are capable

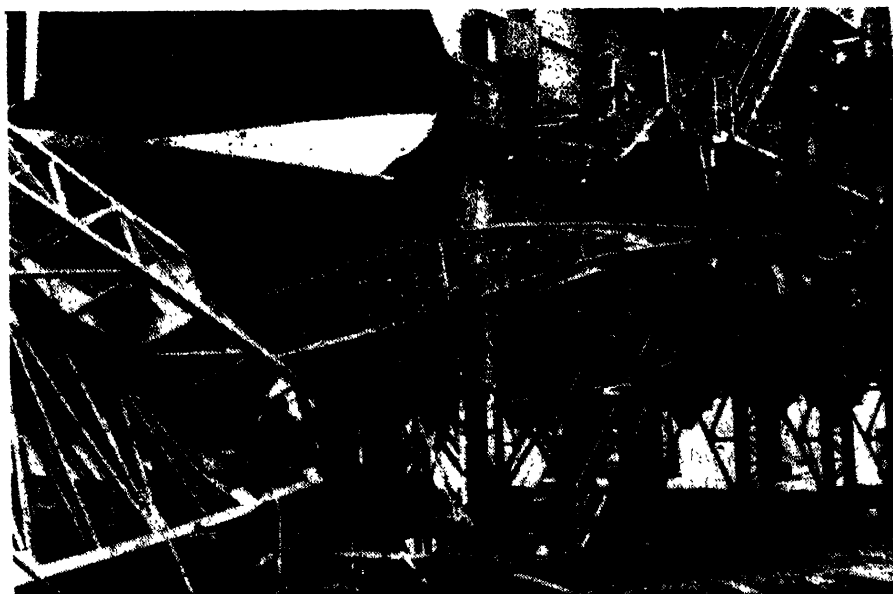


Fig. 5. Destruction of a factory building

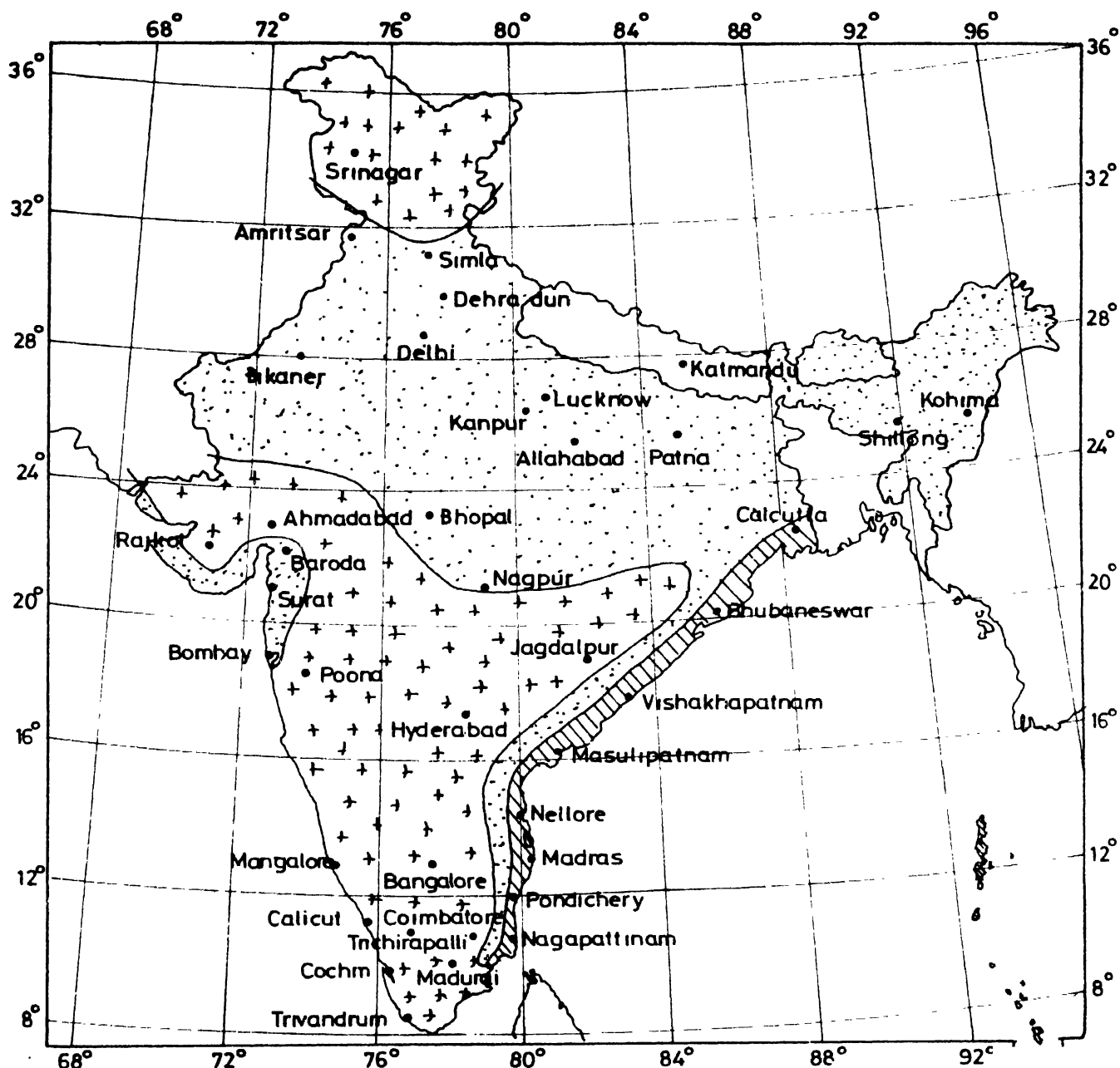


Fig. 6. Basic maximum wind pressure map, including winds of short duration

of resisting horizontal loads, the most common is the wind load, they are often called wind bracings, although other mechanisms such as earthquakes or even eccentricities due to poor construction may give rise to lateral loads on structures.

It is to be noted that a very high wind load is of a rare occurrence

and the design wind speeds specified in most codes of practice may never actually occur in the life time of a structure. Hence, most building codes allow a 25 per cent, and sometimes as much as 33 per cent, increase in the permissible stress for wind loading.

In multistorey concrete build-

ings, shear walls are provided to resist the lateral loads. When shear walls cannot be accommodated into the floor plan of a building, wind loads may be resisted by arranging the structure as a framed tube. This concept was introduced by the famous engineer Fazlur R. Khan of Chicago, U.S.A. In this form of

construction, which is particularly suited to tall, slender buildings, lateral rigidity is provided by closely spaced columns in the outer walls which together form a tube. The tube formed by the outer walls acts in response to wind loads as a vertical cantilever, in which, ideally, the windward and leeward walls form the flanges, and are stressed in direct tension or compression, while the side walls act as webs. For tall buildings this form of construction can be very economic since it is possible to achieve an optimum structure in which wind loads are contained within the 25 per cent allowable over stress. Buildings of this kind have been built more than 40 storeys in height.

### The response of buildings to the wind

Tall chimneys and towers often have natural periods of oscillation of several seconds. For example, the Post Office tower in London has a natural period of about 6 sec., but most ordinary buildings are relatively stiff with natural periods of less than 1 sec. Hence an ordinary building is responsive to short duration loadings and so will respond to short gusts.

The complete destruction of buildings by wind action does not occur often in our country but failures of roofs, particularly roof claddings (asbestos sheets, tiles, etc.) are common. Fig. 5 shows the complete destruction of a partially completed factory building during the recent 1977 Andhra cyclone. Investigations on the maximum gust speeds associated with wind damage to roofs has shown that some damage occurred at gust speeds lower than 30 m/sec. Such gust speeds have a return period of less than 2 years. It has been found that the severity of damage is related to location as well as maximum gust speed. There is a tendency for buildings to be lighter in weights,

hence lightweight claddings are used as roof coverings and these components are most susceptible to short gusts. N. V. Nikitiu, the designer of the Moscow T. V. Tower reported to a congress in 1968 that the design figure for the static deflection of the tower was 5.8 m corresponding to a wind experienced for 1.2 hours in one year and the maximum amplitude of vibration 1.4 m. He expected that the maximum deflection of the tower would be less. No one felt unpleasant vibrations.

### Research in India

The structural damages to buildings due to wind are not well documented in our country. However, much importance has been given to wind analysis of structures. The Indian Standards Institution in its code (IS : 875-1964-*Code of Practice for Structural Safety of Buildings : Loading Standards*) stresses the need for wind analysis. It contains the general principles and design criteria of buildings, chimneys, roofs, arches and butterfly type of structures. The Indian Roads Congress Code also gives criteria for choosing the wind loading on bridge structures. The map of India has been divided into three basic zones of wind pressures which is reproduced in Fig. 6.

Studies on winds and wind resistant structures are conducted by the India Meteorological Department, Bhabha Atomic Research Institute and educational institutions like the Indian Institutes of Technology and Indian Institute of Science, Bangalore. Many municipal corporations insist on detailed computer analysis (on wind analysis) for multistorey buildings.

Computer programmes have been developed by the authors for the wind analysis of multistorey structures, stacks, etc., which can be used to predict the deterministic behaviour due to winds. Development of com-

puter programmes for the non-deterministic analysis of structures is in progress and will be ready in due course.

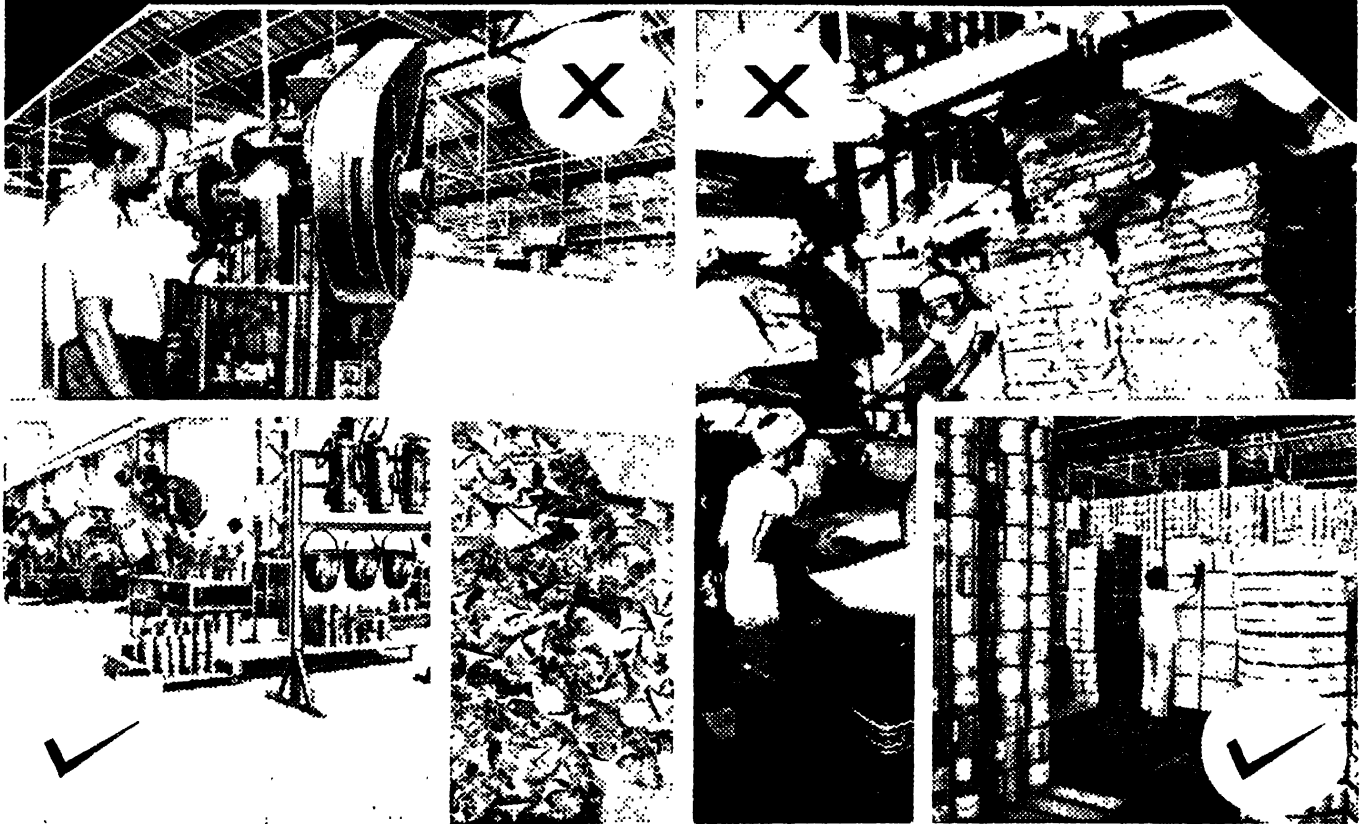
### Conclusion

In spite of the tremendous growth of research in wind engineering, there are a number of uncertainties about the various stages of design due to the random nature of winds. However, these uncertainties can be overcome by rigorous analysis using probability theory and by the long term records of wind data.

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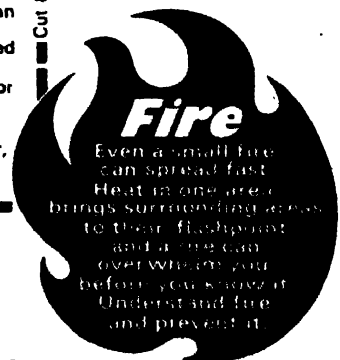
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**G**UMS are polysaccharide hydrocolloids (i.e., form colloidal solutions with water) which find use traditionally in industry for numerous purposes as adhesives, emulsifiers, stabilisers, lubricants, binders, dispersants, suspending and gelling agents, film formers, etc. Gums exert their effect even at low concentrations (<0.5%). They are normally obtained from plants and seaweeds. For example, plant exudate gums (gum arabic, gum ghatti, gum tragacanth, etc.) ; seaweed gums (agar,

industries. They are consumed in large quantities by industry because of their low-cost and their remarkable properties of improving and controlling the qualities of commodities. Because of their wide industrial applications there has been an ever growing demand for the gums and to meet this demand a new class of water-soluble gums known as extracellular microbial polysaccharides have been developed, which can compete with and supplement the natural gums

the remarkably high moisture-holding capacity of polysaccharides enables bacteria to maintain at least some moisture in their immediate environment even after prolonged exposure to low humidity. Also, the thick capsule associated with the extracellular polysaccharide production serves as a physical barrier and provides protection against bacteriophages. The capsule also provides partial protection against phagocytosis and amoebic attack.

Research during the past 20 years



# MICROBIAL POLYSACCHARIDES

a new class of industrial gums

**D. CHANNE GOWDA**

**Research during the past two decades has shown that many species of microbes exude gum-like substances that have wide industrial applications**

algin, carrageenan, etc.); seed gums (guar gum, locust bean gum, tamarind gum, etc.); plant extracts (pectin, larch arabinogalactan, etc.); starch fractions and their derivatives; and cellulose derivatives are used as additives in food, pharmaceutical, cosmetic, textile, paper and other

Polysaccharides that are synthesised by microorganisms and released into the culture media are called extracellular microbial polysaccharides. Microorganisms produce extracellular polysaccharides probably to protect themselves against adverse environmental factors. For example,

has amply demonstrated that a number of microbial species can produce extracellular polysaccharides. Such polysaccharides produced by carefully selected mutant organisms growing on low-cost energy sources such as grain or industrial byproducts like molasses, whey, etc., can offer

Dr. Gowda is Lecturer in Chemistry, Deptt. of P.G. Studies & Research in Chemistry, University of Mysore, Mysore.

a variety of useful and potentially low-cost industrial gums. Several microbial gums with widely different properties are now available, and it is likely that more will be found in the near future.

Interest in this new class of polysaccharide hydrocolloids stems from several considerations such as : (1) successful performance of several microbial polysaccharides in industry; (2) general suitability as food additives and as pharmaceutical ingredients; (3) economic feasibility, as they can be produced from low-cost grain or industrial byproducts; (4) the need to supplement natural plant gums; and (5) synergistic reactions of these polysaccharides with other gums or food ingredients.

Although many microorganisms produce extracellular polysaccharides, only a few of them can convert sufficient amounts of substrates into polysaccharides having properties of commercial importance. Among a substantial number of extracellular polysaccharides that have been studied in order to commercialise them, only two have had good commercial success, viz., (i) Dextran synthesised by *Leuconostoc mesenteroides* NRRL; B-512F strain, and (ii) Xanthan gum produced by *Xanthomonas campestris* NRRL B-1459 strain. (Culture collection by Northern Regional Research Laboratory, U. S. Department of Agriculture, Peoria, Illinois.)

## Dextran

Although several organisms produce dextrans, only dextrans produced by *Leuconostoc mesenteroides* and *Leuconostoc dextranicum* have been commercialised. Dextrans can be produced by fermentation of sucrose either by whole-culture process (fermentation using the microorganisms as such) or by culture-free process (fermentation by extracellular enzyme, dextransucrase, obtained from the microorganisms). In the first method,

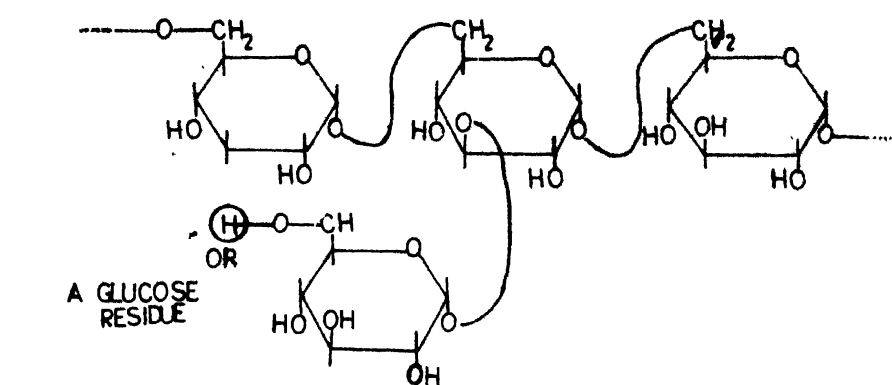


Fig. 1. Structure of the dextran from *Leuconostoc mesenteroides* NRRL B-512 F

suitable pre-cultured microorganisms are added to the liquid media and fermentation is allowed to proceed at specified temperature and pH. The composition of the media and conditions of the fermentation process depend upon the type of bacteria used. For example, the composition of the medium used for the production of B-512F dextran is sucrose 100 g/l; yeast extract, 2.5 g/l magnesium sulphate heptahydrate 2.0 g/l; dipotassium hydrogen phosphate 5.0 g/l. The initial pH is adjusted to 7.0 and the reaction is allowed to proceed at 25°C until the pH reaches 4.8.

In the second method, production of dextran involves two stages. In the first stage the microorganisms are made to produce the enzyme, dextransucrase, in an appropriate

liquid culture medium at specified pH and temperature. In the second stage dextran is produced by simply combining the cell-free medium containing the extracellular enzyme with sucrose. This method gives an uniform material and has several other advantages. It is used nowadays for the production of dextran in the United States, Canada, Sweden, and elsewhere from sucrose using extracellular enzyme, dextransucrase, from *Leuconostoc mesenteroides* strain NRRL B-512F. The bacterial strain is incubated in a medium containing : sucrose, 2.0 g/l; yeast extract, 0.5 g/l tryptone, 0.25 g/l; and dipotassium hydrogen phosphate, 0.5 g/l; at pH 6.7. The dextran is produced by combining the suitably diluted cell-free culture medium at pH 5.0-5.2 with sucrose,

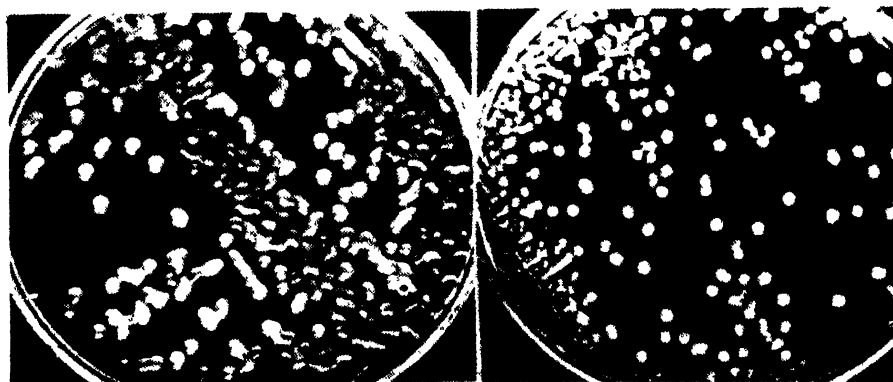


Fig. 2. (left) Strains of *Leuconostoc mesenteroides* with large amount of gummy polysaccharide around the colonies. (right) colonies of *Leuconostoc citrovorum* that produces little gum (After C.W. McCleskey, L.W. Faville and R. O. Barnett) (see p. also)



Fig. 3. *Xanthomonas* species

and allowing the fermentation to proceed at 25°C-30°C.

The dextran is recovered from the culture media, after appropriate dilution and centrifugation to remove suspended impurities by precipitation with one volume of water-miscible organic solvent such as methanol, ethanol, isopropanol or acetone. Purification is done by dissolution in warm water and reprecipitation.

Native dextran, obtained as above, has a high molecular weight (30-90 million) which makes it unsuitable for clinical purposes. Partial depolymerisation of the native dextran by chemical method using controlled acid hydrolysis, enzymic depolymerisation or by subjecting to ultrasonic vibrations, and subsequent fractionation gives a series of lower molecular weight products which are marketed for clinical and industrial purposes. Nowadays clinical dextrans are produced directly by controlled enzymic synthesis by suitably adjusting the composition of the culture medium.

#### Structure and properties of dextrans

Although dextrans from different bacterial strains differ in their physical and chemical properties, all are exclusively composed of  $\alpha$ -D-glucopyranosyl units. Majority

of these units (>50%) are linked through (1→6) glycosidic linkages, the remainder being (1→3), (1→4), and/or (1→2).

Dextran dissolves readily in either warm or cold water to give a clear solution which is stable to sterilisation by heat, and to freezing and thawing. The pseudoplastic nature (the measured viscosity of aqueous solution decreases rapidly with the increase of shear rate) of 15% aqueous solution of dextran is comparable with 1% solution of locust bean gum. Dextrans are digestible and undergo metabolism in the body when fed to man or animals. Because of these properties, dextran is widely used in food and pharmaceutical and other industries. The Food and Drug Administration in U. S. A. has recommended the unrestricted use of dextrans having molecular weight >100,000 in food and pharmaceutical industries.

#### Uses of dextran

Dextran and its derivatives find over 300 clinical applications, but the



B



Fig. 4. (A) Star-shaped 'flocs' of *Zoogloea ranigera* in broth culture, (B) Electronmicrograph showing a cell of *Zoogloea* species (After K.T. Crabtree)

most important of these is as a blood volume extender. Native dextran with high molecular weight is unsuitable. For this purpose, dextrans with molecular weight between 40,000 and 70,000 are used. The biological effect of dextran depends on its molecular weight. The U. S., Swedish and British pharmacopeia specify dextrans with average molecular weight of 75,000. Dextran is used as an antilipemic (fat reducing) agent. Intravenous injection of dextran lowers the cholesterol and total lipid levels in atherosclerotic patients. As a cryoprotective agent it inhibits cell damage on freezing. Other clinical uses of dextran are: as suspending agent in X-ray opaque compositions; as stabilising agent in water-insoluble vitamin preparations; and as binding agent in tablets. The sulphate derivative of dextran is used as an anticoagulant and antilipemic agent, and in the treatment of simple goitre and peptic ulcers. Its phosphate is used as inhibitor of peptic activity; hydroxy-alkyl ethers are used as blood plasma extenders with improved storage qualities; carboxymethylether is used as auxiliary binding substance in tablets, as a carrier in antibiotics, and as encapsulating substance in



Fig. 5. *Azotobacter vinelandii*, a common bacterium of the soil



Fig. 6. *Bacillus polymyxa* (After R. G. Kyckoff and A. K. ter Louw)

microcapsules of menthol, aspirin, etc. The chloral dextran complex, is used to suppress stomach irritation. The iron-dextran complex is used in the treatment of iron deficiency anemia.

In food preparations dextran is used in syrups and candies to improve moisture retentivity and to inhibit crystallisation; in jelly confections as gelling agent; in ice cream to prevent shrinkage and ice formation; in icing composition as stabilising agent; in pudding composition as bodying agent; and in the preparation of bread to improve loaf volume, moisture retention and shelf life. Carboxymethyl dextran is used as fruit syrup thickener and ice cream stabiliser.

In industry dextran finds a wide variety of applications. It is used as an additive for drilling fluids in oil drilling, and in drilling muds as protective colloid. It also finds use in alumina manufacture as a sedimentation agent, in purification of caustic soda to remove iron in the form of iron-dextran complex; and in nuclear fuel production as a complexing agent. Dextran triacetate is used as film former. Its stearates

and palmitates are used in the preparation of 'chemical gloves' which are insoluble in water but soluble in non-polar solvents. These derivatives also find use in waterproofing fabrics, and in improving cohesion of polyethylene coating to metal surfaces. Dextran sulphate is used in photographic emulsions with increased covering power. Dextran nitrate or nitrate-sulphate is used in gelled propellants and explosives. Carboxymethyl dextran is used as a latex stabiliser; in water-emulsion paints; in the preparation of water-soluble films for packaging of detergents, soaps, foods; and in the preparation of aqueous gels and organogels.

Use of dextran has been suggested as a soil conditioner. Certain dextran products when added to the soil enhance seedling emergence and increase plant growth and crop yields. Dextran can also be produced in the soil by the addition of appropriate organisms. Dextran with molecular weight greater than one million improves porosity in soil, water retentivity, and resistance to erosion. Carboxymethyl dextran is used as a carrier in pesticides and germicides, and as a soil conditioner.

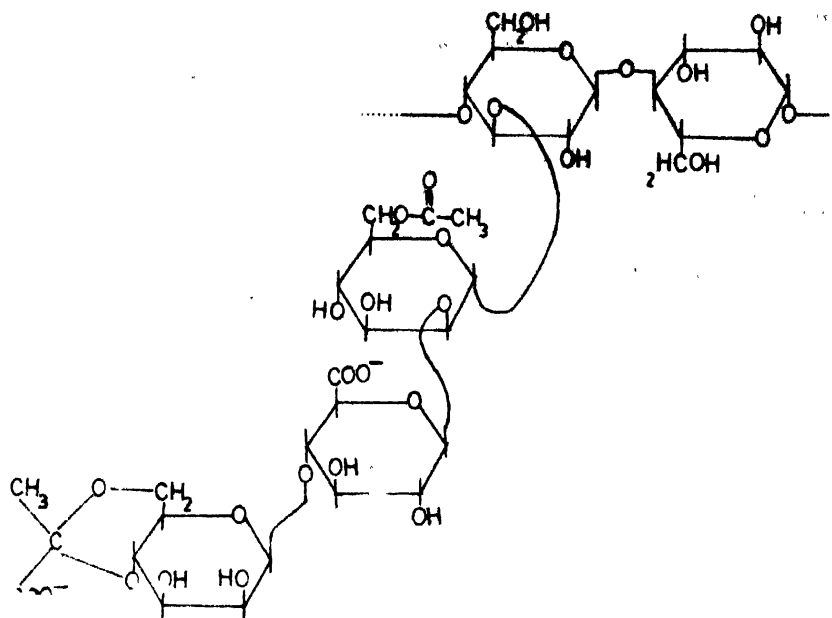


Fig. 7. Structure of the repeating unit of xanthan gum from *Xanthomonas campestris*

### Xanthan gum

Among more than 100 species of *Xanthomonas* known, only a few species, viz., *Xanthomonas campestris*, *X. phaseoli*, *X. malvacearum*, and *X. carotae* are reported to be good producers of extracellular polysaccharides. Of these, the polysaccharide B-1459 (popularly called xanthan gum produced by *X. campestris* NRRL B-1459 strain) has the most interesting properties and finds potential industrial applications. The polysaccharide is commercially produced by aerobic fermentation at 28°C in a medium containing 2.5%-3% of D-glucose, sucrose or other carbohydrates as carbon source, a protein, and an inorganic nitrogen source such as ammonium chloride, 0.5% dipotassium hydrogen phosphate, and 0.01% magnesium sulphate heptahydrate. The initial pH is adjusted to 7.0 and during the fermentation the pH is held at 6-7.5. Maximum gum production is obtained in a period of 2-4 days. Gum is recovered from the fermentation beer, after appropriate

dilution and centrifugation to remove bacterial cell and suspended impurities, by precipitation with a water-miscible solvent such as methanol, ethanol or isopropanol. The recovered xanthan gum is dried, milled and blended to specifications. The production of xanthan gum is genetically controlled both with respect to composition and molecular weight. Thus a product of outstanding uniformity is obtained. Xanthan gum is now available in a number of commercial grades for industrial applications.

### Structure of xanthan gum

Xanthan gum is an acidic polysaccharide with a molecular weight more than a million (4-20 million). It is composed of D-glucose, D-mannose, and D-glucuronic acid in the molar ratio 2 : 2 : 1 and contains 4.7% of O-acetyl groups and 3% of acetal-linked pyruvic acid. The polysaccharide is made up of a pentasaccharide repeating units with the structure shown in Fig. 2. The primary structure of xanthan gum is comb-

like, with a high molecular weight backbone of (1→4) linked B-D-glucopyranose, as in cellulose, but with a three-sugar side chain attached at C-3 to alternative glucose residues.

### Properties of xanthan gum

Xanthan gum dissolves readily in either hot or cold water to give high viscosity solutions at low concentrations; at higher concentration a gel is formed. The viscosity of aqueous solution is nearly independent of temperature over a wide range (between 10°C and 70°C) and of pH (between pH 6 and 9). The measured viscosity of aqueous solutions of xanthan gum decreases rapidly as the shear rate is increased and thus it is highly pseudoplastic. Xanthan gum has good compatibility with high concentration of a wide range of salts. Compatibility of xanthan gum with food grade salts and acids is usually good. Aqueous solutions of xanthan gum on evaporation give strong films which adhere strongly to glass and many metal surfaces. Deacetylated xanthan gum forms stronger and more flexible films than the native polysaccharide. Solutions, emulsions and gels containing xanthan gum have excellent freeze-thaw resistance. The gum when mixed with locust bean gum shows a unique viscosity-increasing and gelation effect. When used as a food ingredient, it gives a good mouth feel and flavour release. The suspending and dispersing ability of xanthan gum is as good as most other hydrocolloids. These remarkable properties of xanthan gum are the basis for its numerous applications in industry.

### Uses of xanthan gum

Xanthan gum is used in beverages to enhance the mouthfeel and flavour release, and as a suspending agent to obtain desirable cloud and pulp in some of the drinks. It is used in canned foods as emulsion

stabiliser and suspending agent, and in the preparation of bread to obtain desirable loaf volume, crumb texture and crust quality. Xanthan gum-locust bean gum gels are used to prepare excellent instant puddings.

In industry xanthan gum is used as a textile print thickener; additive in drilling fluids; emulsifier in latex emulsion paints; suspending agent in ceramic glazes; and as suspending and emulsifying agent in cleaners and polishes. But the most important use of xanthan gum is its use in viscous water flooding to achieve maximum secondary recovery of oil from oil wells. For this purpose, no other hydrocolloid is as versatile as xanthan gum.

Apart from dextran and xanthan gum, several other extracellular microbial polysaccharides have been studied for their possible industrial

applications. But none of them have been commercialised because either their yield is low or their properties do not compete well with other gums. Some of the bacteria which produce water-soluble gums are *Arthrobacter viscosus* NRRL B-1973, *Alcaligenes viscosus* B-182, *Zoogloea ramigera* B-3669, *Hansenula holstii* Y-2448, *Cryptococcus laurentii* var *flavescens* Y-1401, *Bacillus polymyxa*, *Azotobacter vinelandii*, etc. The gums produced by these bacteria are not commercialised because of the above mentioned limitations.

The excellent performance of xanthan gum and dextran is highly promising for further exploration of new extracellular microbial polysaccharides as water-soluble industrial gums which can compete with natural gums. Unfortunately in India no work seems to have been done in this field.

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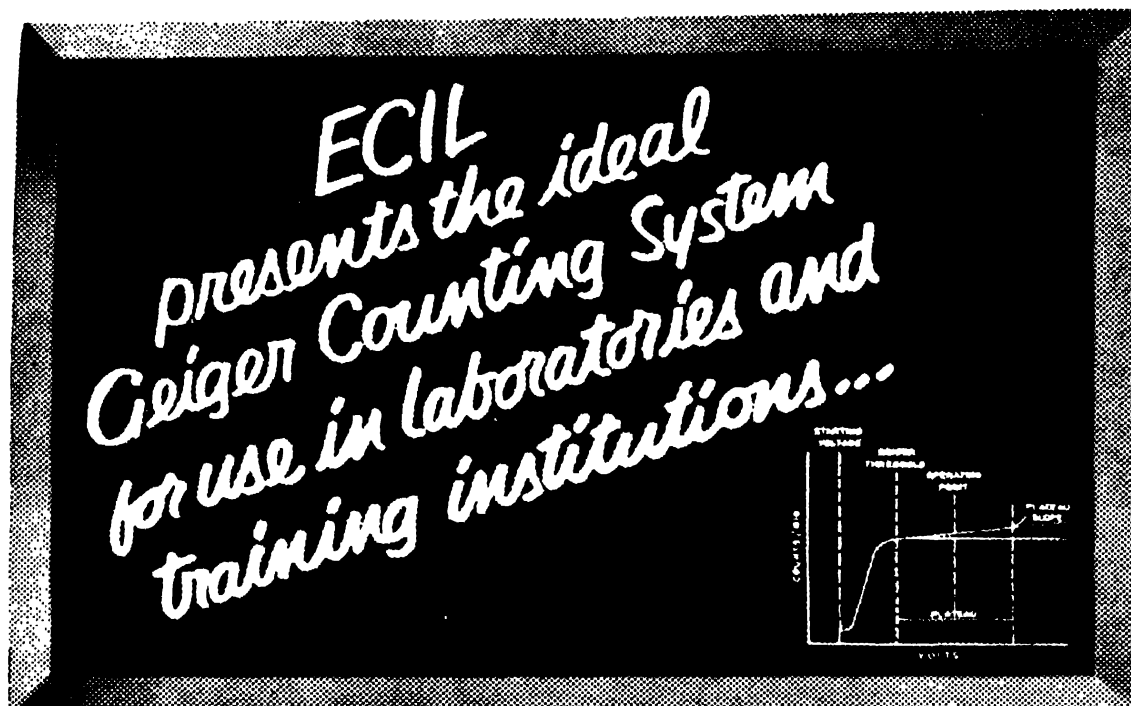
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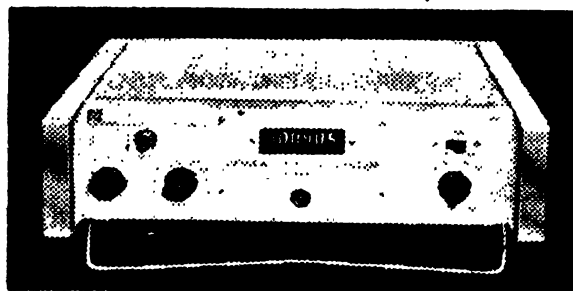
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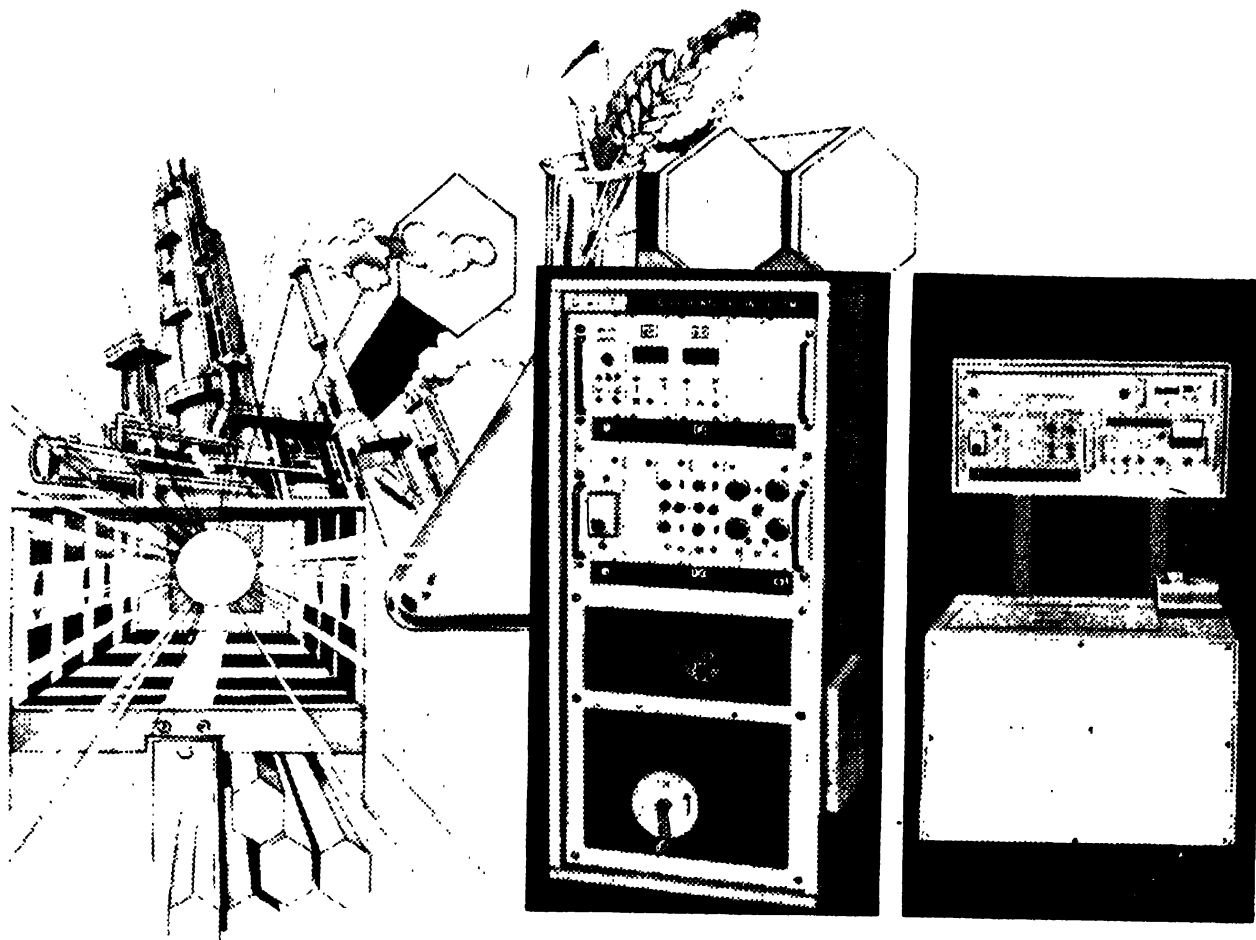
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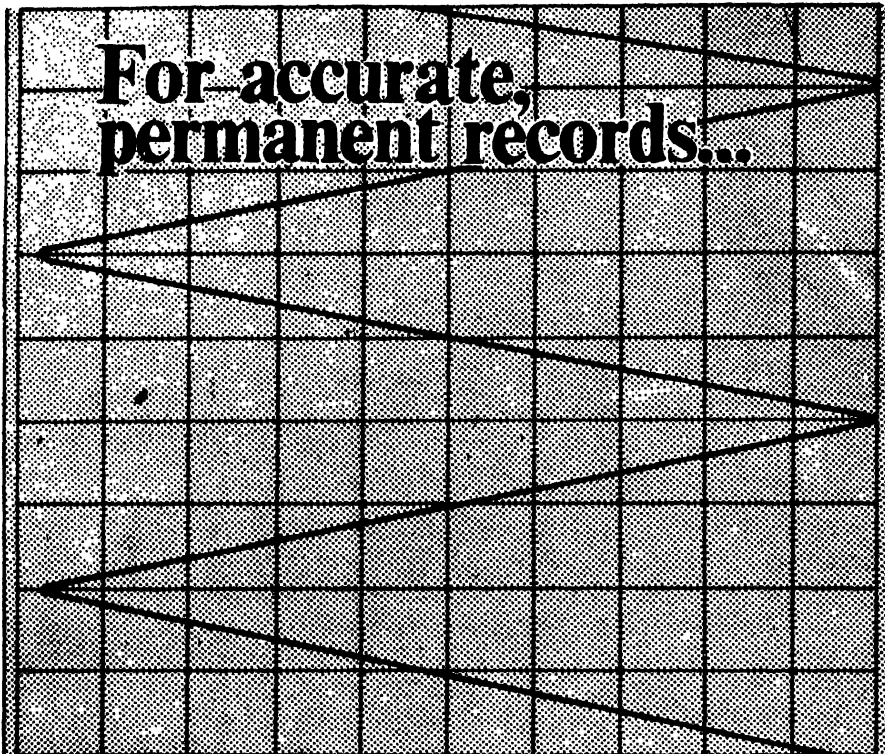
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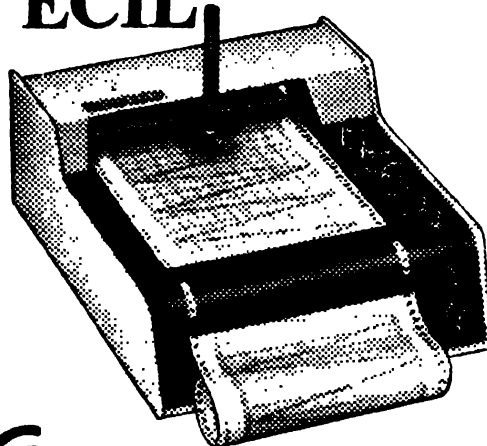


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consists of two rectangular plastic (polyvinyl chloride) pieces encased in stainless steel (4.5 cm × 3.5 cm) frames hinged together in which a special photographic film is sandwiched. Each piece has a set of five filters: 1 mm Cd, 1 mm Pb, 1 mm Cu, 0.15 mm Cu and 1 mm plastic, and an open window as shown in Fig. 2. A portion 5 × 5 mm<sup>2</sup> is cut off from the rear lead filter corresponding to which there is an opening in the stainless steel frame also.

The rationale in the use of the filters is the desirability of identifying the type of radiation to which the film has been exposed. In addition, there is need to identify the quality of the radiation. Such identification of quality of radiation as well as the type of radiation enables assessment of individual components of the doses to be done more accurately. It is extremely important, in case of excessive exposures, that the type or types of radiations involved should be identified so that details of accidental exposure is accurately reconstructed

**T**HE growing use of radioactive materials and other radiation sources for human welfare in the field of medicine (diagnostic and treatment), agriculture and industry gives rise to problems concerning personnel safety. It, therefore, becomes essential to monitor routinely the personnel working with these sources to ensure that they are working within the safe limits, keeping in view the long and short term deleterious effects of radiation exposures.

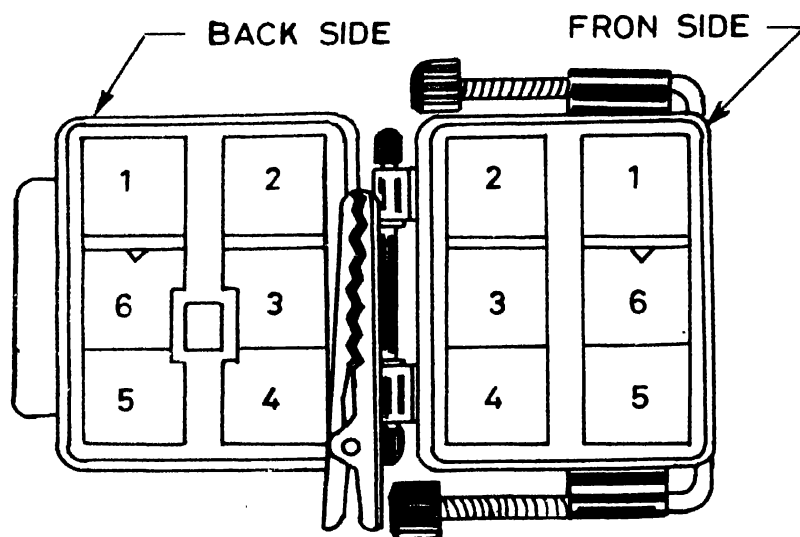
The Division of Radiological Protection (DRP), Bhabha Atomic Research Centre conducts the monitoring programme covering all the atomic energy establishments in the country. Apart from this, there are some 2000 institutions involving 15,000 radiation workers covered under this programme using film badges. The film badge provides a reliable and permanent record of personnel exposures for legal purposes as well as exposure statistics. Additional advantages of film are its small size, ruggedness, low cost and simultaneous recording of more than one type of radiation. This badge is worn by the worker on the chest level (Fig. 1) thereby giving an estimate of the wholebody dose.

The badge is also worn on wrist by the radiation worker to estimate the dose to the hand at the time of fluoroscopic examinations of patients as well while working with discrete sources.

The film badge developed by DRP



Fig. 1. Radiation worker in the diagnostic room. The arrow shows the film badge he wearing



1. OPEN WINDOW 2. PLASTIC 3. CADMIUM

4. THIN COPPER 5. THICK COPPER 6. LEAD

Fig. 2. The film holder and the various filters incorporated therein

and appropriate corrective action taken to avoid incidence of such exposures subsequently.

The Kodak Radiation Monitoring film (41 mm × 31 mm) is being used for monitoring purposes. This film is specially designed for monitoring radiation exposures of individuals. From the processed film, an adequate assessment of a very wide range of exposure to radiation is made. This is achieved because of the coating of two emulsion layers of different sensitivities, one on each side of the film base, usually cellulose acetate. Both emulsions are used to measure small amounts of radiation exposures. When large doses are to be measured, the more sensitive emulsion is scraped from the film base after processing, leaving the less sensitive emulsion intact.

Over the emulsion surface, there is a very thin protective gelatin layer of thickness about 0.5 microns. Gelatin in the emulsion supports the grains permanently and permits ready access

for processing chemicals to the grains. It also plays an active part in the photographic process as its composition influences the sensitivity of grains and also takes part in energy transfer to the grain. The incident radiation transfers some of its energy to the silver bromide crystals thereby raising the energy of one or more electrons into the conduction energy band of the crystal. These electrons travel through the crystal until trapped in the impurity centres in the crystal lattice. The electrostatic potential set up about these centres attracts the very small fraction of silver ions in the crystal which are free to migrate. Under continuing exposure, these two processes will continue until silver clumps, containing several silver atoms each, are distributed in the crystal. They are called latent images. During development process, these clumps catalyze the chemical reduction of the remainder of ionic silver in the grain to metallic silver. The developer serves mainly as a reducing agent. The metallic

silver gives rise to actual blackening of the film. The more the radiation exposure the deeper is the blackening. Blackening below various filters is measured and compared with the calibrated films and the quantity of exposure is estimated.

The badge is capable of monitoring exposures to thermal neutrons as is the case with personnel working around a nuclear reactor. The film area under the cadmium filter is made use of. Thermal neutrons produce a density under cadmium through gamma rays produced in the  $^{113}\text{Cd} (n, \gamma) ^{114}\text{Cd}$  reaction. Any excess density observed under the cadmium filter over that expected from the gamma dose received by the person is attributed to thermal neutrons.

For fast neutrons, Kodak neutron monitoring type-A film mounted in a polythene bag is used. The fast neutron dose is evaluated from the number of proton recoil tracks per unit area of the developed film. The recoil proton tracks are produced due to the elastic collision of neutrons with hydrogen atoms in the emulsion, the film base and the paper wrapping. These proton tracks are counted under high magnification by optical microscopes.

All the institutions covered under this programme are supplied with the requisite number of films by DRP along with one or more control films every month. The control film is kept at a radiation free place where radiation workers keep their badges after doing their routine radiation work. These films are returned along with the control film. This control film, after development, provides information about the radiation background which is used for correction purposes of the actual exposures.

The exposed films are processed in batches of 1000 along with a set of calibration films under standard conditions. The optical density on each developed film is measured and

compared with that of the calibration film. Thus, the dose of the individual is estimated.

The dose records of the personnel are sent to their respective institutions and are properly maintained at DRP also. In case a person has received a dose higher than that specified by the International Commission on Radiological Protection, the institution authorities are informed about it, in order to keep him off

the radiation work for appropriate time. The service is in vogue for the last twenty years in the country.

S. J. SUPE

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## Wool and its chemistry

**W**OOL is an animal fibre. It is similar in origin to a number of mammalian epidermal tissues like horn, hoof and nails. Chemically, wool is a protein—keratin.

Like all other proteins, wool is also made up of amino acids. The amino acids are joined end-to-end in the form of peptide chains to form long-chain molecules. These polypeptide chains are joined in chains through cross-linkage which give wool many characteristic structural and tensile properties. Polypeptide chains in wool occur normally in folded form and these chains can be unfolded on stretching the fibre. The folded form of this fibre is designated as alpha-keratin and the extended form as beta-keratin. Two sulphur containing amino acids found in wool as well as in other keratins are cysteine and methionine. Many of the physical and chemical properties of wool are due to the disulphide bonds formed by covalent cross-linking of the amino acid residue cysteine. Any chemical that weakens or destroys disulphide bonds may cause structural breakdown of the fibre.

Many other acidic and basic side chains are also present in the

polypeptide chain of wool. The presence of these side chains cause the formation of 'salt-linkage' which are responsible for the amphoteric nature of wool, i.e., it behaves both as acid and base. The peptide chains are held together also through hydrogen bonding which are responsible for elastic properties of individual wool fibre. Electron microscopic examination of wool fibre has revealed that polypeptide chain in wool are in the form of a helix.

Dry wool fibre swells when placed in water, the degree of swelling depends on such factors as the temperature of water and strain on the fibre. In cold or lukewarm water the fibre swells about 10% in diameter, but on drying the fibre usually returns to its original size. This recovery is thought to be due to reversibility of hydrogen bonding transformation. This explains the important property of elasticity of wool. Fibres dried in extended state do not recover their original size. If sodium bisulphate solution is used, permanent pleating may be achieved due to the formation of the disulphide bonds in new positions

When wool is heated in dry air at 100°C to 105°C over a long period, it loses moisture and the fibres become harsh, if returned to moist air, the fibre rapidly reabsorbs moisture and regains its softness. Wool, when burnt, emits a characteristic odour like that of burning of hair or feather, probably due to the presence of nitrogen in the keratin. The vapour coming off during burning has an alkaline reaction and probably contains ammonia. Although it burns, wool is fire resistant. When removed from the flame, wool fibre assumes a knob or charred globule on its end but does not continue to burn.

Oxidising agents like hydrogen peroxide, potassium permanganate, potassium dichromate, chlorine dioxide attack cysteine disulphide bonds, resulting in decreased sulphur content, strength and fibre weight. The main use of oxidising agent is in bleaching. Hydrogen peroxide is the most common bleaching agent used for bleaching wool and gives the best permanent white.

When wool fibre is exposed to light in presence of water, reaction between water and cysteine linkage takes place. This photochemical reaction is responsible for the yellowing of woollen fabric. So, white woollen garments should not be dried in bright light.

Wool is more hygroscopic than other textile fibres. This characteristic confers a number of advantages on wool as a clothing and furnishing fabric. The actual mechanism of water uptake by wool is ill defined. Initial absorption of water is believed to be due to a chemical process where heat is released. The heat raises the temperature of wool and lowers the relative humidity in the immediate vicinity of the fibres. This has a stabilising effect on the relative humidity.

The association of anions of strong acids with wool are fully reversible, and the wool in combin-

ing with acid suffers no permanent alterations. But at high temperatures, the main peptide chains of wool are hydrolysed by strong acids and under prolong treatment may result in breakdown of wool fibre into its constituent amino acids. Degradation of wool by treatment with alkaline solutions is one of its most characteristic chemical properties. Such degradation is associated with the instability of the cysteine disulphide bonds towards alkalis. So in general, whenever woollen fabrics are treated with alkaline solutions, care should be taken to give the fabric a most thorough washing in order to remove as much alkali as possible. Certain acid treatments may also be useful to facilitate this removal. If this is not done, alkali spots may form after drying, storing and may also result in weakening and discolouration of the fabrics.

Because of the large number and wide variety of functional groups present in wool, it is probably the most reactive of all textile fibres towards dyestuffs. The central portion of the fibre called orthocortex is heavily dyed with basic dyes. This is surrounded by a portion called paracortex which is chemically less reactive. Wool fibres also possess more affinity for anions. The process of dyeing also depends on the rate of attainment of equilibrium between ion exchange process. The few basic dyes which are used to dye wool (e.g., methylene blue and the Rhodamines) are usually applied in a neutral or weakened solutions to reduce alkali damages.

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## Bioacoustic control of bird pests

**S**MALL areas of crops can be effectively protected from bird damage with fishnets which have become fairly popular in home gardens. For large-scale cultivated crops this solution is neither practical nor economic. Methods most frequently employed by farmers are scaring by yelling, beating empty metallic tins, pelting stones with local devices called gophans and putting models of hawk and man's effigy in the field. But their efficacy is limited by the rapidity with which birds become accustomed to them. Chemical repellants used so far are not satisfactory. Moreover, pesticides raise residue problem causing contamination and pollution.

Almost all living beings respond to sudden loud sounds. From the housewife who shouts and claps her hands to scare the crows to the farmer who beats empty metallic tins to disperse the bird pests damaging the crop, all utilise sound for food protection. These loud sounds may be effective only for short durations since birds usually become used to them after some time.

### Communication signals

The discovery of the tape recorder for recording, storage and delivery of communication signals has opened a new branch in bioacoustics for the study of control of bird pests. The method has three advantages over the usual noise-producing devices such as percussion instruments, empty metallic tins, fire-crackers and acetylene explosions :

(i) Communication signals are effective at low intensities above the noise level; (ii) As reactions are instinctive habituation is usually slow; and (iii) Signals may be specific to drive away only one species or non-specific dispersing a wide variety of species.

Bird calls can be classified as follows :

(i) Pleasure calls, (ii) Food finding calls, (iii) Assembly calls, (iv) Nest calls, (v) Mating calls, (vi) Flight calls, (vii) Territorial defense calls, (viii) Aggressive calls, (ix) Fretting calls, (x) Distress calls, (xi) General alarm calls, and (xii) Specialised alarm calls.

Alarm and distress calls have significant role in dispersing the bird pests from food areas. Distress calls are the communication signals emitted by birds when they are in distress or otherwise restrained. Broughton designates desperation calls of adult birds as distress calls and the signals of juvenile birds when disturbed, hungry, etc., as fretting calls. Alarm calls are emitted by free birds when they observe a predator or some other alarming circumstance. Generally alarm calls are sharp variously repeated notes, discontinuous in emission, restricted in frequencies and clearly patterned in time. Frequency of the alarm call depends upon the type of threat and species. Birds, merely disturbed, emit low intensity slow-paced calls while the same birds under severe threat shriek with sudden excitement.

The behaviour of bird pests towards distress or alarm calls varies with the species. Starlings are repelled by broadcasts of their distress signals. French corvids are first attracted to the source of signal and later disperse separately. Gulls of a number of European species show the same type of response. In England some

birds like Oystercatchers are attracted by distress calls and do not disperse. Some birds like Laysan Albatrosses do not respond at all to the distress calls. A series of experiments conducted by American and French workers have revealed the existence of dialects in the language of birds. At Maine, gulls responded towards their recorded distress calls whereas the same species in Holland did not react towards the same calls. It shows the differences in dialects among geographically isolated populations of the same species. Since the responses of birds to the distress and alarm calls vary with the species, they should be studied under field conditions to assess their effectiveness.

In 1953 Frings and Jumber conducted the first experiments to disperse the starlings from their tree roosts in urban area by using records of starling distress calls. The results seemed to be promising though there was slow habituation. They observed that 'the distress call seems to be quite species-specific.' In 1967 Pearson *et al.* observed that starlings were not habituated to distress calls and grackles were also dispersed by the starling's distress calls contrary to the findings of Frings and Jumber. Bunsel and Giban demonstrated that corvids could be dispersed from food areas by reproducing their distress calls. In Germany, Switzerland, America and France scientists obtained excellent control of starlings and black-birds in urban and agricultural problem areas. In Holland and Britain, gulls were controlled at airports by broadcasts of their distress calls. At present bioacoustic method is an effective tool to disperse birds at airports in most of the countries.

In India, bioacoustic control of bird pests is in initial stages. Since 1978 such studies have been undertaken in the scheme for biology and

control of bird pests at Andhra Pradesh Agricultural University, Hyderabad. A series of experiments have been conducted in the Agricultural research fields to disperse baya weaver birds from their roosting bush. About 350 of them were causing heavy damage to the surrounding experimental paddy fields. Amplified distress calls were sounded in evenings when bayas returned to their roosts. The experiment was repeated at irregular intervals of two to seven days to overcome habituation. Bayas were first attracted towards the source of signals and later dispersed in groups. The number of bayas gradually decreased up to thirteen days and finally no single baya was seen arriving at the night roost. The response of the Indian bird pests such as parakeets, sparrows, bayas, crows, pigeons and munias towards alarm and distress calls is yet to be studied in detail.

#### Recording of distress and alarm calls

The recording equipment—microphone, pre-amplifier and recorder—should be capable of recording frequencies of at least 50 Hz–40,000 Hz, have high signal-to-noise ratio and be very sensitive to transients. The frequency specification upto 40,000 Hz is imposed to cover ultrasonic frequencies in bird calls. Such recording equipment is expensive and is not easily available in the market. The bird should be at least one meter away from the microphone while recording, otherwise the microphone overloads and distorts the signals. Distress calls can be recorded in laboratory by gently squeezing the neck of the bird. For efficient recording of alarm calls in fields a parabolic reflector should be used to eliminate stray noises. It serves to receive as many weak alarm signals as would be collected by the ordinary microphone from the close source of sound. In Germany, Reich *et al.* were initially unsuccessful in starling

control. Crenz *et al.* showed later that earlier failures were the result of low fidelity of the recording equipment.

For successful bioacoustic control experimental trial of birds the following factors are important.

- (i) Identification of the bird pest and other species associated with them;
- (ii) Nature of the problem (roosting, feeding, resting, etc.);
- (iii) Size of the areas to be protected;
- (iv) Size and composition of the flock;
- (v) Period of protection of the crops;
- (vi) Environmental conditions (weather, etc.);
- (vii) Behaviour pattern of the bird pest and other associated species;
- (viii) Factors that could interfere with application of sounds (background noise, activities of persons, etc.);
- (ix) Proper intensity and high fidelity of the communication signal; and
- (x) Effective time intervals between displayed signals to overcome habituation

Even for long periods of control no habituation of the birds to their communication signals has been reported. The few reported cases of habituation were realised later to be due to defects in the recording and reproduction systems of the communication signals. Bioacoustic control of birds is an efficient method for protection of crops and dispersal of birds from airports and urban roosts. The method is pollution free and leaves no residual problems as in the case of pesticides.

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## Plant insecticides

WE are all aware of the fact that plants are important to us: they provide us with food, shelter, clothings and medicines. Apart from these important uses, they are of insecticidal value too. Plant insecticides are of low mammalian toxicity and never harm the predators in the food chain. Romans and Chinese used naturally occurring insecticides from plants and animals. Natives of the tropics used leguminous plant products as stupefying agents in fishing. Chinese were the first to discover the value of Derris (*Derris elliptica* and *Derris malaccensis*) as an effective insecticide. In India, plant products have been used as insecticide since ancient times. Their use can still be observed in the rural and tribal areas.

Chemical substances like alkaloids and isoflavonoids present in plants are the active principles which act as insecticides. Alkaloids such as nicotine from tobacco (*Nicotiana* spp.), rotenone from Derris (*Derris elliptica*) and pyrethrins and cinerins (pyrethroids) from pyrethrum (*Chrysanthemum cinerariifolium*) are good plant insecticides. Most plant insecticides act as contact poisons being absorbed through the cuticle of the insects.

"Leguminosae" or the "Pea family" has several plants known to have promising insecticidal values. Logwood (*Haemotoxylon campechianum*) extracts are used in controlling the Japanese beetle. Alcoholic extracts of roots of the fish-poison climber (*Millettia pachycarpa*) control bean aphids. This plant contains two insecticidal compounds known as rotenone and saponin which act as contact and stomach poisons. Rotenone is a complex isoflavonoid

placed in the group "Rotenoids" obtained from the roots of the genera *Derris*, *Lonchocarpus* and *Tephrosia*. Roots of "devil's shoe-string" (*Tephrosia virginiana*) contain rotenone. It is effective against flea beetles, blossom weevils, aphids, apple suckers and caterpillars. In the East Indies and South America, powdered roots of leguminous shrubs such as *Derris elliptica* are used as the source of rotenone in pest control. Extracts of Derris roots mixed with Pyrethrum are also used as insecticidal sprays. Rotenone is not harmful to man.

Plants belonging to the "Solanaeceae" or "potato family" are also promising insecticidal plants. The active principles in these plants are alkaloids called "Solanaceous alkaloids". Anabasine is obtained from the tree tobacco (*Nicotiana glauca*). Crude extracts of its leaves can be used to control aphids. Nicotine, an alkaloid obtained from tobacco (*Nicotiana* spp.), is graded as a contact insecticide. Nicotine fumigation kills many insect pests. In India

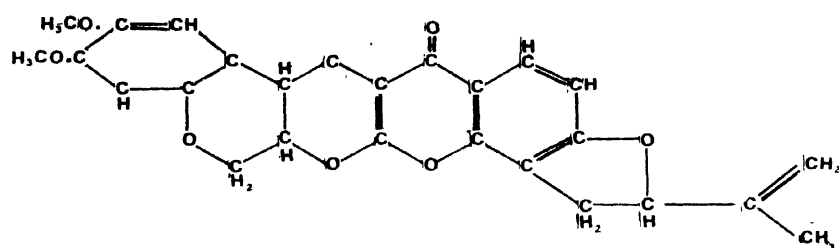


Fig. 1. *Millettia* sp. twig with inflorescence

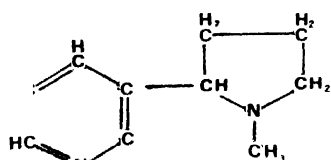
practices like spraying of the water extracts of tobacco stems, leaves, etc., for pest control are still prevalent. Another practice widely followed in India, especially in rural areas, is the application of ground tobacco for plant protection. Nicotine sulphate, a commercial compound obtained by the action of nicotine with sulphuric acid, is used as a contact spray. Nicotine is highly volatile, its conversion into the sulphate lowers its volatility. Nicotine sulphate sprays effectively control aphids, flies, leaf-hoppers, thrips and several types of caterpillars. Nicotine dust mixed with gypsum or clay and nicotine sulphate is a promising insecticide against beet leaf hopper, sweet potato weevil, tobacco hornworm



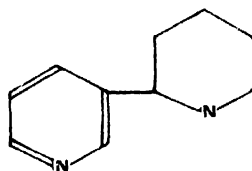
Fig. 2. Inflorescence of pyrethrum (*Chrysanthemum cinerariifolium*)



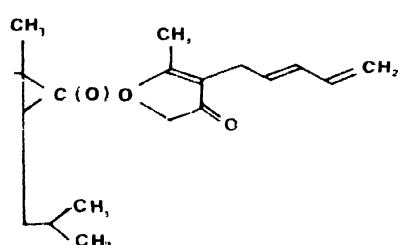
ROTENONE



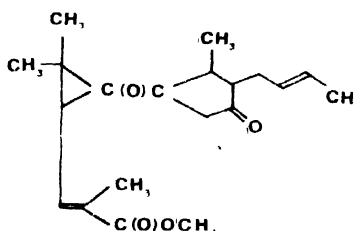
NICOTINE



ANABASINE



PYRETHRIN I



CINERIN I

Fig. 3

and onion thrips. Nicotine base is also a promising fumigant. Nicotine fumes, obtained by evaporating liquid nicotine base over a heater or by burning nicotine, are important in

Fig. 4. *Nicotiana glauca* twig with inflorescence

green house fumigation. There are several other Solanaceous plants that contain promising insecticidal properties.

Pyrethrum (insect powder) is obtained from the floral parts of *Chrysanthemum cinerariaefolium* belonging to the "Compositae" or "Sunflower family". It is a safe, promising, household insecticide used either in sprays or dusts. Japan is the chief pyrethrum exporting country followed by Yugoslavia, Kenya and Southern Brazil. The active principles in pyrethrum are pyrethrins I and II and Cinerins I and II. They are unstable compounds as they decompose when exposed to air and sunlight. Pyrethrins are axonic, contact and stomach poi-

sons. They are non-toxic to human beings. Their action is similar to that of DDT. Domestic insect pests such as cockroaches are effectively eradicated by the application of pyrethrum sprays.

Pyrethrum is used in following ways :

(1) As pyrethrum dust, popularly known as insect powder; (2) Oil extracts; and (3) Water-soluble extracts.

Plants like Castor (*Ricinus communis*), Common basil (*Ocimum basilicum*), Cockroach plant (*Haplophyton cimicidum*), China berry (*Melia azedarach*), Caraway (*Carum carvi*), Coriander (*Coriandrum sati-*

Fig. 5. *Derris elliptica* twig with inflorescence

vum, Anise (*Pimpinella anisum*) and several others also have effective insecticidal properties against many domestic and agricultural pests.

We are all familiar with the serious environmental pollution caused by application of synthetic insecticides and pesticides, like organochlorine and organophosphorus compounds. The environment can be saved from the agrochemical (insecticides and pesticides) pollution if more use is made of the safe and effective, naturally-occurring plant insecticides.

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## Lichen—an idyllic consortium

THE lichens are an association of fungi and algae which have formed a new morphological entity completely different from either of their separate components. The term 'lichenised fungi' is now used synonymously with lichens to reflect the fact that the greater part of the mass of most lichen thalli is composed of fungal hyphae with the algae restricted to a thin layer near the surface.

The lichen association seems to have developed a physiological system to scavenge essential minerals as well as organic requirements from its nutrient, poor habitats like rock surfaces and tree trunks where other forms of life are unable to gain a foothold. It has been strongly established that photosynthetically fixed carbon moves from alga to fungus mainly as glucose and polyols (ribitol), erythritol, sorbitol, etc.). In lichens containing *Trebouxia* and *Nostoc*, atleast 70% to 80% of the carbohydrates fixed by the alga pass to the fungus. On removal of algal components from lichen, this carbohydrate flow declines immediately. Why does this close association in lichen cause a massive efflux of carbohydrates from alga? D. C. Smith of Botany Department of the University of Bristol, BS8 (1975) has suggested that such an existence has some effect on the membrane transport system to stimulate the efflux. It is suggested that the fungus might be able to reduce the algal membrane potential so as to cause a net efflux of certain molecules. Whatever the theory may be, the central point is the physical attachment of the fungus to the alga. The fungus restricts the ability of alga to grow, so that the 'space' for storing carbon in the cell is limited and a surplus is generated.

### Aliphatic and alicyclic substances

- Group 1 Acids
- Group 2 Triterpenoids
- Group 3 Polyhydric acids

Lichens with blue-green symbionts show active nitrogen fixation and substantial transfer of fixed nitrogen to the fungus. They are transferred in organic forms, mainly as neutral amino acids like alanine, glutamine or as peptides. There are also reports regarding the transfer of nitrogen in the form of ammonia.

### Morphogenetic interaction

When grown in isolated culture, the lichen fungi show none of the elaborate morphology and tissue differentiation. The alga, when isolated, regains its growth habit. So what is the reason that evokes the remarkable morphogenetic response of a new thallus formation? It has been suggested that this morphogenetic change may be partly due to the natural environmental conditions and partly due to association with

alga. Whether this morphogenetic change is due to some secretion of morphogens by the alga or an aspect of the physical contact or a phenomenon of catabolic repression is yet

Table I

### Aromatic substances

- Group 1 Pulvic acid derivatives
- Group 2 Depsides
- Group 3 Depsidones
- Group 4 Quinones
- Group 5 Xanthone derivatives
- Group 6 Dibenzofurane derivatives

to be known. But each partner affects the morphology of the other in a highly specific way.

### Adaptation to habitat

The development and distribution of lichens are intimately associated to their habitat. Based on the habitat, the lichen communities fall into various categories: (a) *Arboreal* (corticolous)—which grow on leaves, bark and wood; (b) *Terricolous*—ground lichens; (c) *Saxicolous*—rock lichens; (d) *Omnicolous*—which exist in most varied substrate; and (e) localized communities.

Irrespective of habitats, this composite structure that acts as a functional unit seems to have evolved its ability to withstand extreme drought as well as the ability to scavenge essential minerals. Lichens can harvest a considerable amount

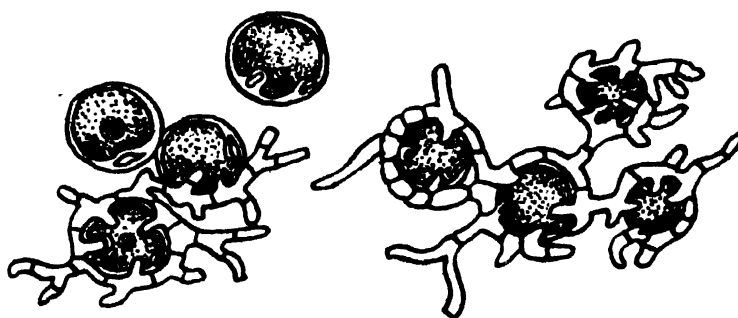


Fig. 1—Haustoria of lichen-fungi surrounding the symbiotic algae



Fig. 2. *Cladonia* sp. (lichen) British soldiers

of certain solutes from the liquids passing over them in their habitat. There are two efficient mechanisms of solute accumulation—active uptake, and passive binding to the cell walls. Sugars, amino acids and phosphates are taken actively by lichens. Substantial amount of cations like iron, copper, etc., are accumulated by passive binding to cell walls. Most binding sites are located in the fungal hyphae, since the latter are proportionately abundant and possess much thicker walls than algae.

Almost all lichens lose water and dryout often to 10% or less of the dry weight of the thallus. The reason why almost all lichen require periodic drying still remains obscure. It may be necessary for the flow of nutrients, and the physical shrinkage and expansion may be an essential feature of substrate attachment.

#### Growth of lichen

Lichens are among the slowest growing plants known to botanists. They grow at lobe and branch tips as such their radius, circumference and length increase at a constant rate. The thickness of the thallus

remains more or less constant and its older parts remain alive and intact.

Why does a lichen grow so slowly? It has been suggested that low protein synthesis rate may be one reason and this may also be an adaptation to poor nutrient supply. The slow growth rate may also be due to

environmental conditions which only allow lichens brief periods of metabolic activities such as assimilation. Recently, a new concept—physiological buffering—has been introduced to explain the slow growth rate of lichens. The important feature of this concept is that the disturbances caused due to environmental fluctuations are mainly confined to the physiological reactions involving polyols. Polyols have a number of roles in lichen: (a) they act as substrate for both basal and resaturation respiration, (b) their high concentration in cytoplasm generates a high osmotic pressure, essential for plants normally living under conditions of water stress, and (c) they may protect macromolecules during drying out by direct substitution of water molecules. Much of the fixed carbon is accumulated in the polyol pool and there is a continuous loss of carbon from this pool as it carries out this function. So a high concentration of polyols is essential for the existence of lichens. When polyol concentration fluctuates with environment, it may especially 'buffer' the growth process.



Fig. 3. *Parmelia capetra* (lichen on rock), Great Smoky Mts., National Park, USA

### Chemistry

Amongst the chemical constituents of lichen substances lichenin, isolichenin, hemicellulose, fatty substances, amino acids and growth substances are important. Besides them, lichen excretes a number of organic compounds which become encrusted as crystals on its surface. Table I shows various lichen acids obtained from lichens.

### Economic uses

**Food.** *Cladonia alpestris*, *C. rangiferina* and *Cetaria islandica* are useful as fodder for reindeers and caribon in the Arctic regions. They are known as 'reindeer moss'. The Berber tribes in the deserts of Libya graze their sheep on the crustose lichen, *Lecanora esculenta*. It can never be considered as a food for the growing world population due to its slow growth rate and poor yield.

**Medicine.** The lichen *Lobaria pulmonaris* is used to treat lung diseases. Rabies is cured by taking powdered *peltigera* with black pepper and warm milk in required proportion. This lichen was named by Linnaeus in 1753 as *Lichen caninus* or 'dog lichen'. Many of the lichen products are antibiotic in nature. Gram-negative bacteria (rods) as a rule are resistant to all lichen acids, but gram-positive bacteria and tuberculosis bacillus are inhibited by protolichensteric acid, usnic acid, etc. Usnic acid is widely used in European countries as a chemotherapeutic drug for external application.

One of the drawbacks of lichens is that they are insoluble in water and unless a water soluble derivative could be found it will have little therapeutic value. We can expect, however that lichen antibiotics will become increasingly common in medical practice in future.

**Soil formation.** Lichens happen to be the first plant group that took part in active soil formation. Earlier

it was thought that lichen acids played an important role in this direction but due to low acidity and solubility of these acids they were found of no significance. Another view is that the gelatinized lichen thalli break off chips of rocks as they expand or contract when wet or dry. It is also believed that lichen acids can disintegrate rocks by chelation, a process that removes calcium, magnesium and other minerals from crystals.

Besides these, extracts of *Evernia*, *Parmelia* and *Ramalina* species contain various essential oils that are extensively used as soap scents. Future studies may throw light on this mutualistic association of alga and fungus and exploit them for the benefit of mankind.

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## Low lactose in milk and milk products

MILK is a major source of animal protein. Besides, it provides fat, carbohydrates, minerals, vitamins and other growth promoting substances. Lactose, a disaccharide of glucose and galactose, is the principal carbohydrate of milk and the enzyme hydrolysing it into constituent monosaccharides is known as lactase or  $\beta$ -D-galactosidase (EC. 3.2.1.23). Majority of people are unable to utilize milk properly because of their sensitivity to lactose due to lack of intestinal  $\beta$ -D-galactosidase. Consumption of milk by lactose intolerant persons results in gastrointestinal disturbances like abdominal pain, diarrhoea and flatulence. There is high incidence of lactose intolerance among the adult populations of Asia, Africa, Latin America and the Middle East. The etiology of lactose intolerance is controversial and it could be due to environmental or genetic factors. Attempts have been made to develop a process for preparing dairy products in which lactose is partially or completely removed. This can be achieved by several methods, but the most promising appears to be hydrolysis of lactose by  $\beta$ -D-galactosidase.

This will also remove the problem of gritty texture in concentrated dairy products due to crystallization of lactose.

$\beta$ -D-galactosidase is found in many plants, animals and also in microorganisms. However,  $\beta$ -D-galactosidases of microbial origin is inexpensive and its case of production can be profitably exploited for application in food industry. The microorganisms producing  $\beta$ -D-galactosidase include yeast, molds, and bacteria. Yeast enzyme is generally recognized as safe and no toxicological problems arise causing contamination of milk. Also, the yeast enzyme possesses an optimum pH for activity which is quite near the pH of the milk. Various studies have shown that the yeast *Kluyveromyces fragilis* produces the enzyme in appreciably good quantities and hence is best suited for use in food industry.

Enzymes have been used for various industrial processes in their soluble forms but the use of soluble form of enzymes makes the process economically unprofitable. This problem can be overcome by the application of immobilized enzymes.

The immobilized derivatives of enzymes are prepared by attaching enzyme molecules to solid matrices which render them insoluble and enables the use of enzyme columns in continuous processes. The immobilization is affected by any one or by the combination of different techniques like adsorption, covalent bonding and gel entrapment. Several organic and inorganic substances, viz., controlled pore glass beads, collagen, acrylamide polymers, cellulose triacetate fibers, sepharose and ion-exchange resins are used as carriers for immobilization of enzymes. Collagen as the support for immobilization offers several advantages over other supports like its inexpensiveness, requirement of simple immobilization techniques and mild conditions and high swelling capacity in aqueous solutions. Recent studies have shown that im-

mobilized whole cells could serve as enzyme source.

The lactose reduced milk has been used for the preparation of various dairy products like yoghurt, ice-cream and non-fat dry milk and the products were reported to be of good flavour, appearance and stability. Hence, the simplest way to reduce lactose content of milk is by passing it through a column of *Kluyveromyces fragilis* cells immobilized on collagen and the treated milk can be used by lactose intolerant persons or can be used in the preparation of various low lactose dairy products.

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## Interferon

**I**NTERFERON is a new drug derived from the body for its own defence against viruses. It was discovered 20 years ago by Alick Isaacs and J. Lindemann of National Institute for Medical Research in London during their studies on viral interference. In the interference phenomenon, infection of a cell by one virus renders the cell resistant to superinfection with other viruses (Fig. 1). The illustration shows that interferon, is a small protein, which is released from the host cells during viral interference and that it confers protection against virus infection upon other cells. However, interferon has been very difficult to extract from the body and therefore its use as a drug has been an extremely slow process until recently. Interferon also suffers from another disadvantage,

that is, unlike other biological substances, which can be used interchangeably between species, interferon from lower mammals does not work in man. Interferon obtained only from the higher primates alone works in humans.

Interferon is protein in nature having molecular weight around 20,000. As already mentioned, interferons synthesized by different cells or species show some dissimilarities, but whether these differences lie in the amino acid sequence of the proteins, in the carbohydrate content, or in some other feature is not known. The human leucocyte interferon is stable. Interferon is thus a protein hormone, and acts as a "pan-vaccine" because it attacks almost any virus. It has therefore considerable advantage over vaccines, which

are effective only against the specific virus from which they are derived. This versatility is a wonderful attribute when it comes to fighting, say, the cold viruses, which mutate constantly and exist in some hundred odd varieties. It is, therefore, extremely difficult to tackle all varieties of common cold viruses with a single vaccine, or even a combination of them. But, interferon works marvellously against all viruses.

Interferon works in an animal body in a variety of ways and they are listed in Table 1. The most important action of interferon is to inhibit the replication of viruses. It provides umbrella protection against most animal viruses, although the sensitivity of different viruses may vary greatly. The other main property of interferon is its ability to inhibit cell division (cytostatic). However, higher doses of interferon are needed to achieve the cytostatic effect than are needed for the antiviral effect. Recently, a variety of other *in vitro* and *in vivo* effects of interferon have been demonstrated. For example, interferon has immunosuppressive effect, which may represent a manifestation of its inhibitory action on the division of B and T lymphocytes. Although it has been mentioned that interferon is species specific, there are many exceptions to this rule. For example, human leucocyte interferon exerts antiviral activity in monkey, cow,

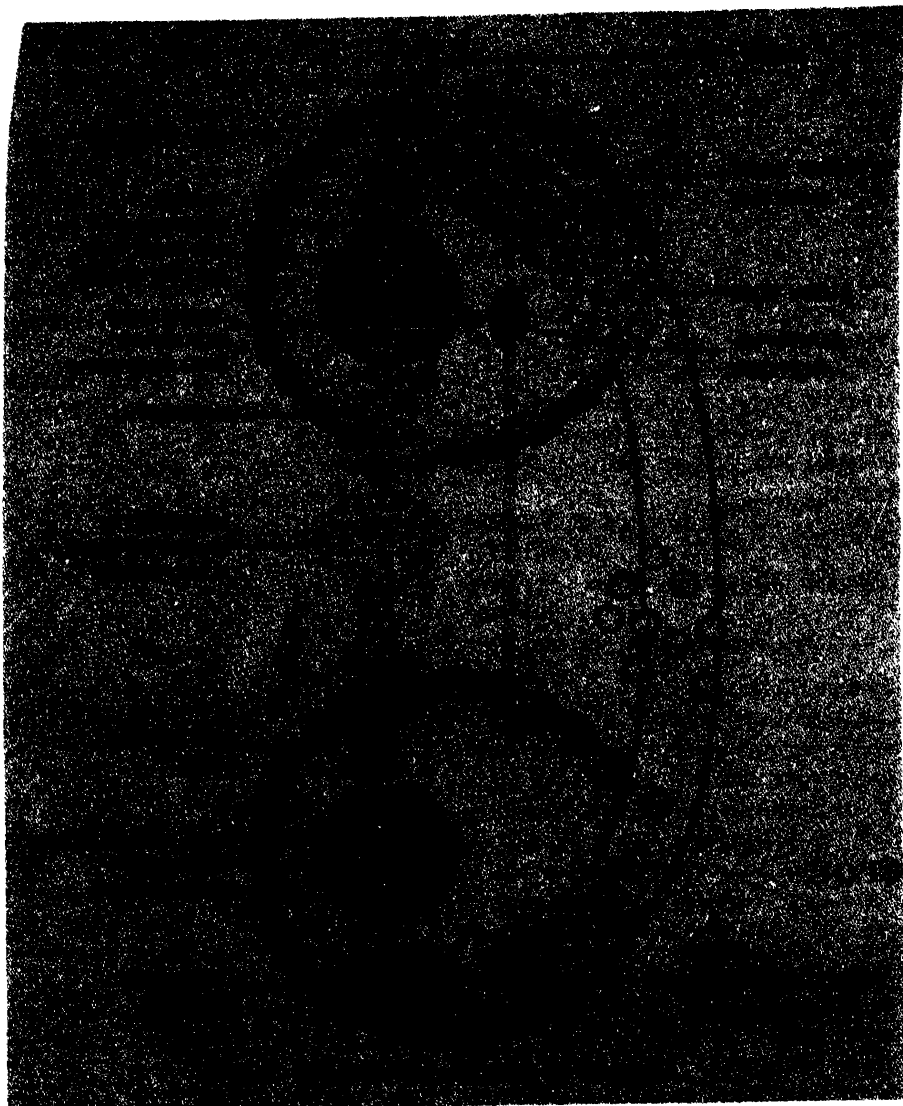
Table 1. Effects of interferon

### Inhibition

- Multiplication of animal viruses.
- Intracellular growth of some micro-organisms.
- Cell division.
- Antibody production, delayed hypersensitive reaction.

### Enhancement

- Expression of some antigens at cell surface
- Cytotoxicity of lymphocytes
- Phagocytosis



pig, rabbit, cat, and guinea-pig cells. However, only human and monkey interferons are effective in human cells.

The mechanism of action of interferon as an antiviral agent is demonstrated in Fig. 1. It is bound to a receptor at the cell surface, and this receptor is at present the target of active research. One component of the receptor appears to be the glycolipid ganglioside. When interferon binds to the receptor, alterations take place at the cell surface, and some of the effects of interferon may be ascribed to these changes. The antiviral action of interferon is mediated,

however, by a second protein that is induced by interferon. Even after best efforts, this protein has not yet been isolated and its mode of action has not been clarified. Recently, some efforts have been made for the mass production of interferon so that its biological potentialities can be fully evaluated and put to full use to alleviate human suffering. Interferon can be derived from various sources such as leucocytes, amnion, fibroblasts and lymphoblastoid, fibroblastoid and epithelial cell lines. However, at present leucocytes are the main source of interferon, because leucocytes have little clinical

use, and in transfusion may indeed be even harmful. So these normal human cells hitherto useless in transfusion bottles can be put to better use of interferon production. For this purpose, blood is taken from a donor into a 4.0 ml plastic bag which is centrifuged to separate plasma, leucocytes and red cells (Fig. 2). The leucocyte-rich middle layers can be harvested without any significant loss of plasma or red cells. After they have been purified, leucocytes can be induced by Sendi virus to yield interferon. The leucocytes in one 400ml bag of blood yield about 1-2 million units of interferon. By this method about  $10^{11}$  international units of human leucocyte interferon were first produced in 1976 in Finland.

Interferon is not without side effects, for example, pyrexia is the main feature in malignant patients undergoing systemic therapy. In some patients there develops a transient decrease in the number of blood platelets and white cells (thrombocytopenia and granulocytopenia). However, interferon has certain advantages over chemicals and vaccines. For example, chemicals which are used as drugs are always associated with side effects and that vaccines are virus specific. In contrast, interferon is a broad spectrum protein hormone which acts against most animal viruses without damaging the cells in which the viruses are growing. Similarly interferon appears to have a potential for combating infections caused by protozoans, as well as similar organisms, that are closer to human cells in their organizational complexity than bacteria, and consequently are harder to treat with chemicals without damaging the cells. Herpes infection of the eye will illustrate this point well. Interferon was designed to interfere specifically with structural buildup of the viral particle during its replication without affecting body cells too much. In most cases, however, it is hard to target specifically on the viruses since

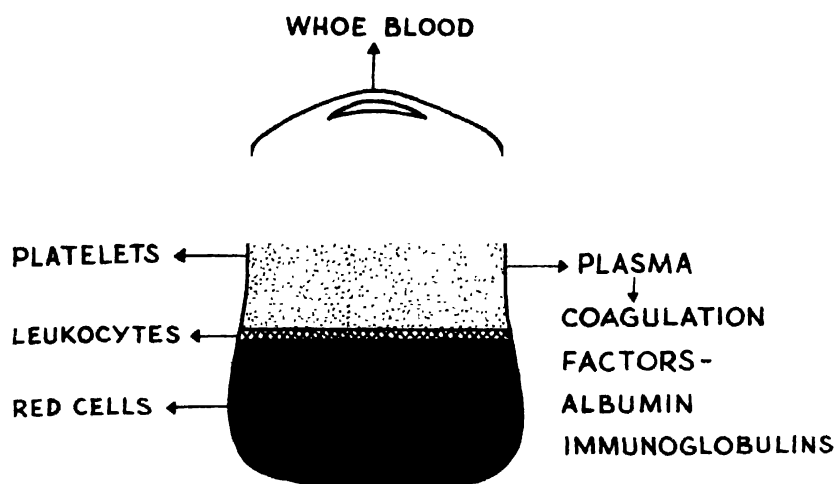


Fig. 2. Transfusion plastic bottle of whole blood showing leucocyte-rich middle layer which is a rich source of human interferon

they become living only after they enter a living cell and utilize some of the cell machinery. A chemical attack by the drug on the virus, therefore, is likely to damage the cell also. Another advantage of interferon in the therapeutic arsenal of medical sciences is that it can be administered directly, or the body can be induced to produce its own interferon supply. In 1975, Thomas C. Merigan and his associates at Stanford University School of Medicine reported successful treatment of chronic serum hepatitis through daily injections of interferon. He further suggested that common cold and influenza can be treated by a device which might be applied under the eyelid which slowly diffuses interferon through the nasolachrymal ducts into the upper respiratory tract.

Many clinicians all over the world are eager to test this potent physiological hormone-interferon in the prevention and/or treatment of a variety of diseases, but because of limited supply of human interferon it has been tried against only certain specific diseases, viz., herpes virus infection in the eye, very dan-

gerous viral infections, viral infections in kidney transplant patients,

viral infections and graft versus host disease in bone marrow transplant patients, viral infections in patients with malignancies, chronic active hepatitis B, etc. It has also been tried as cytostatic agent in certain tumors, viz., osteosarcoma, papilloma, myeloma, breast and lung cancers. Much clinical and experimental work is needed before we know how, when and where to use this substance so as to exploit fully its therapeutic potentialities for prevention and treatment.

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## Bidi plant—a green coin of forests of Indian peninsula

**B**IDI plant is a species of great economic importance. In addition to use of its leaves in Bidi making the plant plays an important role in rural perspective. In botanical language it is known as *Diospyros melanoxylon*. The plant is known by different local names in different parts of the country, viz., in Hindi—*Tendu*, Marathi—*Tumri*, Telugu—*Tunki*, Tamil—*Karai*, Oriya—*Kendu*, Gujarati—*Tamurgu* and in Malayalam—*Kari*. Bidi plant was first described by Roxburgh (1824) and stated to be a native of most woody mountainous countries with frequent distribution in tropical dry deciduous forests of peninsular India. Hooker (1882) stated that the plant is restricted to India and Ceylon. The river Ravi is said to be its

north-western limit of distribution. It is found abundantly in Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa and also occurs in Uttar Pradesh, Rajasthan, coasts of Malabar and Coromondal (Fig. 1).

### The plant

Plants are usually small to moderate sized but occasionally occur as large trees. Leaves are opposite, subopposite or alternate, broadly ovate, elliptic coreaceous and varying much in size and form, upper surface shining green and tomentose to glabrescent beneath; venation uncostate reticulate, bark grayish black, exfoliating in rectangular scales. The tree is extensively used by villagers and tribals for diverse

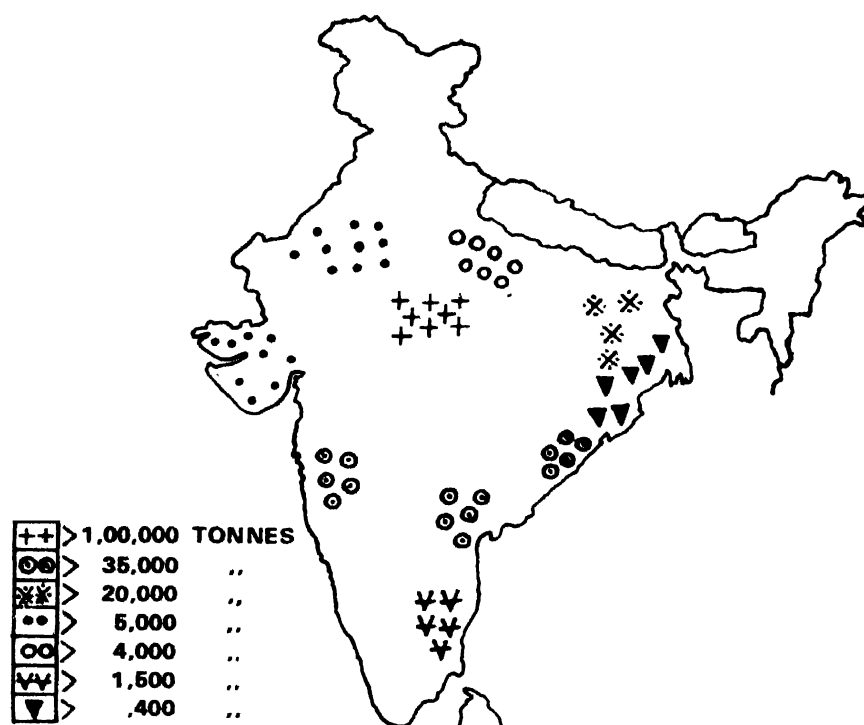


Fig. 1. Distribution of bidi plant and production of bidi leaves in tonnes/year in India.

domestic purposes, therefore its growth is arrested to a bushy nature. The tree grows well in a variety of soils and subsists even on degraded and very poor sites. It is a good coppicer, roots are largely superficial; they give out root suckers.

#### Economic uses

Some species of *Diospyros* are said to yield gum and resin. The tree bark possesses astringent properties and its decoction is used in diarrhoea and dyspepsia. In dilute form it is used as an astringent lotion for eyes. Roxburgh says that the bark, powdered and mixed with pepper is given for dysentery. The ripe fruits are eaten by natives.

The plant provides valuable timber used for building, shoulder poles, carriage shafts and the ebony for all fancy works and carving. According to Lisboa, its heavy, close and evengrained wood takes a fine

polish. The black heartwood is also used for cart wheel and for agricultural implements. Villagers exploit this species for many other purposes including fuel.

Table 1. Bidi leaf production—contribution of different states (*Small Scale Industries No. 2*, published by Forest Research Institute and College, Dehra Dun, 1974)

State	Quantity of Bidi leaves produced	
	Tonnes	Percentage
1. Madhya Pradesh	1,23,000	41.0
2. Orissa	50,000	16.5
3. Maharashtra	45,000	15.0
4. Andhra Pradesh	39,000	13.0
5. Bihar	24,000	8.0
6. Rajasthan	6,500	2.2
7. Uttar Pradesh	5,000	1.7
8. Gujarat	5,000	1.7
9. Tamil Nadu	2,000	0.7
10. West Bengal	500	0.2
<b>TOTAL</b>	<b>3,00,000</b>	<b>100</b>

#### Use of leaves in bidi making.

Young tender leaves of bidi plant are used for bidi manufacture. New flush of leaves appears in February and depending upon local atmospheric temperature, it may extend upto mid-June prior to commencement of monsoon. Leaves are plucked from bushes only, which are generally pruned, coppiced and pollarded. These silvicultural operations result in the production of much larger, thinner and very plastic leaves which are considered to be good for bidi making.

Characters like texture, relative thickness of midrib and lateral veins, size of leaves, the agreeable flavour, flexibility and resistance to decay are particularly important parameters of leaves considered while selecting the leaves for bidi making.

#### Economic aspects of 'bidi' manufacture

Bidi making started in India during 1887 and became so popular that it is now one of the biggest cottage industries in the country. India's share in the world production of bidi is 85% and about 3 lakh tonnes of bidi leaves are collected annually.



Fig. 2. A *Tendu* bush with new flush of leaves

Contribution of different States is presented in Table I.

A handsome revenue is earned by the forest departments of various bidi leaf producing States. The gross revenue earned by certain States during 1972 is given below : —

	(Rs. crores)
Madhya Pradesh	.. 16.80
Maharashtra	.. 5.27
Andhra Pradesh	.. 4.26
Uttar Pradesh	.. 1.86

It is estimated that about 140 crore bidis are manufactured in India per day and have enormous internal consumption. India holds the monopoly in export of bidi and bidi leaves. Bidis are exported to countries like Afghanistan, Bangladesh, Sri Lanka, Canada, Java, Nepal, Singapore, U.K., U.S.A. and several African countries.

#### Bidi plant in rural aspects

Bidi industry is a premier cottage industry in India and spreads almost all over the country in urban as well as rural areas with about 2171 registered factories. This industry has great importance in rural aspects. Bidi is the cheapest form of smoke and, therefore, it is more popular in rural areas and among poor people. Bidi making is a com-

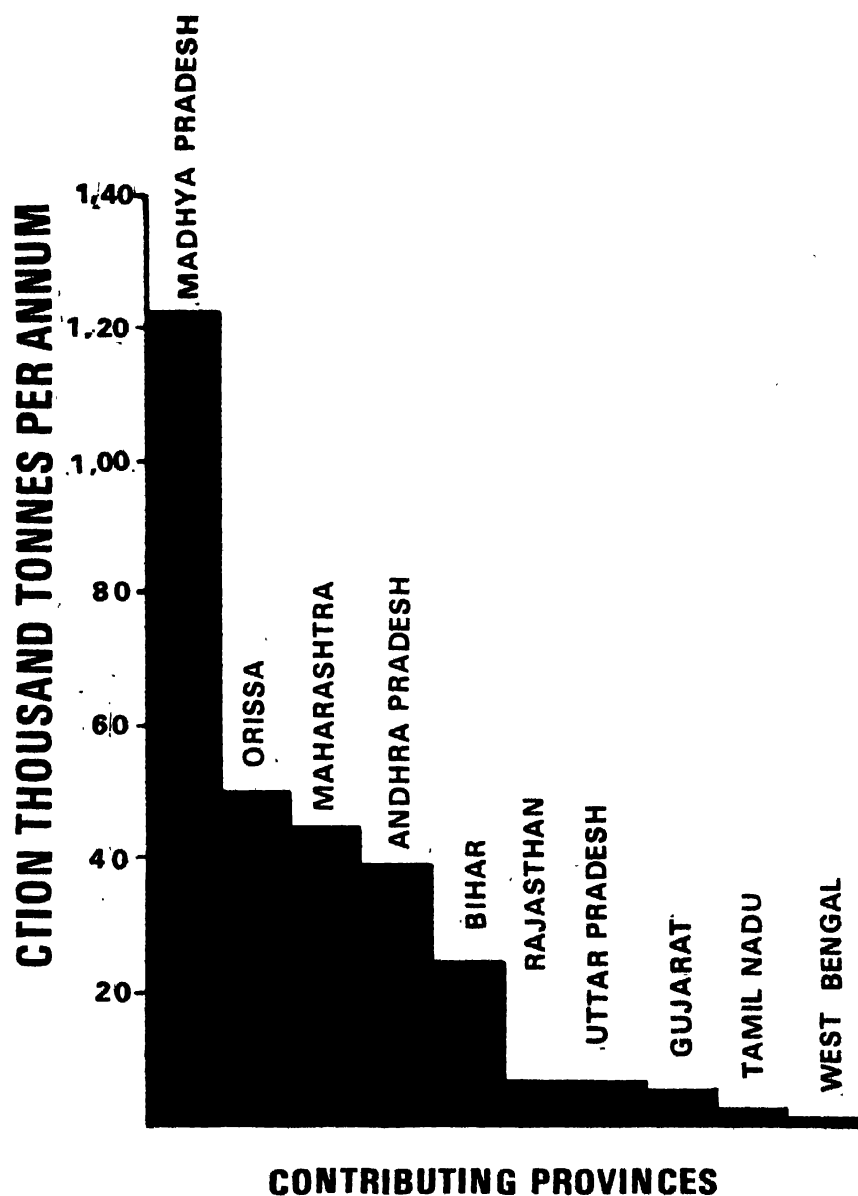


Fig. 3. Production of bidi leaves in different States

pletely manual work and no arduous labour is involved at any stage. Bidi rolling is the primary job which is very simple and can be done at any place at any time; there is no compulsion about the work. It is a source of subsidiary occupation and supplementary income to lakhs of poor rural folk. Bidi industry provides employment to the rural population during off season for collection of bidi leaves. About six lakh people are employed in collection for six to

eight weeks and one to two lakh people are employed in manufacture of bidis for about 300 days in a year. Obviously bidi industry has a vital role in rural welfare and in promoting the rural economy.

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## Wealth from waste

**U**SED, unwanted or discarded materials in solid form resulting from normal community activities are termed as 'solid wastes' and they include garbage, rubbish street sweepings, ashes and other industrial wastes.

Due to rapid industrialisation, more and more people are migrating into towns and cities every year. As a result, there is significant increase in the generation of solid wastes and at present in India, the per capita production of solid wastes is about 0.3 kg per day in urban areas and about 0.15 kg per day in rural areas.

In many urban communities refuse is often handled without any regard to sanitation standards, likely health hazards and aesthetic value. Improper disposal of solid wastes in open dumps contributes to air pollution, surface and ground water contamination. It also creates potential breeding places to disease carrying vectors such as flies, mosquitoes and rats. Accumulation of litter, refuse, junk causes fire hazards, contributes to accidents and also spoils the beauty of towns and cities. Therefore, keeping in view the severity and magnitude of this problem, the municipalities and corporations of the respective towns

and cities should adopt safe and economical methods of collection and disposal to prevent the environmental pollution and nuisance.

### Collection

Collection and transportation of solid wastes play an important role in the solid wastes management, as about 85 per cent of the total expenditure is normally incurred on this job only. Collection operation includes the establishment of methods of refuse pick-up to be used, the types of equipment that are to be employed and assembling of collecting crews. The success of any collection system will depend largely on the proper selection of equipment. Presently in India, refuse is collected from individual streets by manual labour and transported to the disposal sites by vehicles such as bullock-carts, open trucks and tractor-trailers, which is not desirable from hygienic and aesthetic view points. Therefore it is suggested that mechanized closed body vehicles equipped with tipping devices may be used for this work for better results.

### Characteristics

Knowledge of physicochemical

characteristics of solid wastes is essential for selecting proper disposal method. Important characteristics of solid wastes in India are : paper (3% to 7%), plastics (0.6% to 0.9%), metals (0.5% to 1.0%), glass (0.3% to 0.8%), ash and fine earth (30% to 46%), compostable matter (33% to 42%), nitrogen (0.5%), carbon (12% to 15%), phosphorus (0.6%), HCV 1450 to 2000 BTU/, 450g and density 300 to 550 kg/cu.m.

### Reuse and recycling

When materials such as metals, plastics, paper, glass form a significant part of solid waste stream, it is desirable and economical to reclaim and re-use them either directly or by converting them into more useful products as this would reduce the volume of solid wastes to be disposed of and would also yield significant salvage and resale income.

This aspect has been seriously thought of as a possible solution to the disposal of solid wastes in most of the advanced countries. In the U.S.A., materials such as metals, rubber, plastic, glass and paper that are available in large quantities in the solid wastes are being re-cycled to earn considerable resale income. The chemical energy and chemical constituent values contained in the wastes have suggested recovery of these resources by means of a promising process, Pyrolysis. In this process the organic fractions of the refuse are heated in either an oxygen free or low oxygen en-

Fig. 1. Compost plant flow diagram

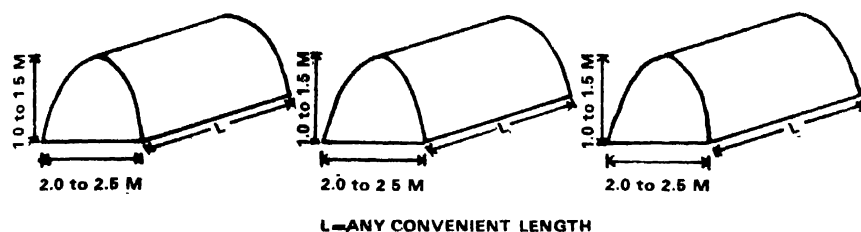


Fig. 2. Arrangement of windrows

vironment at about 1000°F to 2000°F to produce valuable hydrocarbon fuel oils or gases. Presently in India reclaiming is not practised by municipal authorities. But normally unauthorised scavengers collect materials such as metals, rubber, glass, etc., when the refuse comes to disposal sites daily.

### Disposal techniques

(i) *Composting*. It is a biological method of modification of the composition of the organic matter, resulting in a stable end product known as compost. In this process bacteria, fungi, molds and other saprophytic organisms feed upon the organic matter such as vegetable matter, animal manure, etc., and bring down its energy level considerably. Then the organic matter is said to be stabilized and does not pose any health hazard.

In fact, composting is best suited to Indian conditions, because of two acute problems the country is facing (1) safe disposal of solid wastes; (2) considerable reduction in the fertility of agricultural land. As city refuse contains good amount of compostable materials (organic in nature) aforesaid problems can be solved to a great extent by composting the same. Moreover, as the land availability is better in this country, economical methods of composting may be adopted to produce compost at cheaper rate and 'windrow method' of aerobic composting is well-known. Composting process can also be done anaerobically in large tightly packed stacks or pits

and digesters with 60% to 70% moisture content. As the process is very slow, it takes a long time for complete decomposition. When the organic fraction of the solid waste is decomposed under anaerobic conditions (in the absence of oxygen), in closed digesters under controlled conditions, a mixture of methane (60% to 70%) and carbon dioxide (30% to 40%) is liberated which is popularly known as 'biogas'. Due to high calorific value, the gas may be used as a source of heat energy in daily life. The digested sludge so obtained in the process may conveniently be used as manure on fields after drying the same.

To increase the production rate of compost, mechanisation of composting process is essential. The Committee on urban wastes in its report favoured the setting up of mechanical compost plants in all big cities, taking into account local conditions. According to the Committee, it will be considerably cheaper to manufacture compost mechanically than chemical fertilisers on an equal plant nutrient basis. Even if the sale price of compost is fixed at about Rs. 80/- per tonne, it should find a ready market.

(ii) *Sanitary land filling*. It is a method of disposing of refuse on land without creating nuisance or hazards to public health or safety, by utilising the principles of engineering to confine the refuse to a smallest practical volume and to cover it with a layer of earth at the conclusion of each day's work or at such more frequent intervals as may be

necessary. Therefore this is a proper method where there are low-lying areas around the city. Land reclaimed by this method can be utilised conveniently for playgrounds, parks, and other light structures. This method is not suitable where the ground water table is very high, because of ground water contamination.

(iii) *Incineration*. This is a waste disposal process by means of which combustible solid wastes are converted through controlled combustion to a residue that is virtually inorganic in nature which further causes no health hazards. This is not a final disposal method, because the end product (ash) is still there for disposal.

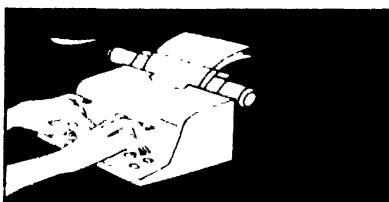
Incineration can be adopted as a method of disposal when land suitable for sanitary filling is not available within the economical haul distances from the sources of refuse. Heat that is generated during the process can be utilised for various industrial uses such as production of steam in thermal power plants, etc. This can offset the operation costs to some extent. In India, incineration is rarely practised and should be encouraged where conditions are favourable.

### Conclusion

Proper collection and disposal of solid wastes is thus an integral part of any attempt at upgrading environmental quality in urban areas and so municipalities and corporations should take effective steps in this regard. As much of the success in all such programmes depends on the whole-hearted support of citizens, it is very much necessary to educate the common man for proper implementation of such programmes.

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## NEWS & NOTES

### Prof. Nurul Hasan is CSIR Vice-President

CSIR's recently appointed Vice-President Prof. Saiyid Nurul Hasan is an internationally eminent historian and educationist. Prof. Hasan was Minister for Education, Social Welfare and Culture in Mrs. Indira Gandhi's earlier Government. His association with science and technology has been longstanding and deep. He is a Foreign Member of the USSR Academy of Sciences. He was convenor of the panel appointed by the All India Congress Committee on Science & Technology in 1969.

Born at Lucknow on 26th December, 1921, Prof. Hasan was educated at Allahabad and Oxford in England from where he took his Doctorate in History. He was recipient of Carnegie Fellowship for research.

He took active part in India's freedom movement during his student days and was Founder Member

and Member, Working Committee, All India Students Federation. Starting his career as a lecturer in Lucknow University (1942-49), he became lecturer, School of Oriental and African Studies, London in 1947-48. Later, he was Reader in History, Aligarh Muslim University (1949-54) and Professor in that department in 1954. He became Head of the Department of History and Director, Centre of Advanced Study of History, Aligarh Muslim University (1958) and Dean, Faculty of Arts (1966-68). He was a visiting Fellow of All Souls College, Oxford, 1968-69.

Prof. Hasan has been associated with several Advisory Boards and Review Committees in the fields of history, educational research, archaeology, history of science and museums. He presided over the Mediaeval India Section, Indian History Congress in 1961, was Secretary, Indian History Congress 1965-67 and its General President in 1973-74.

At international level, he has been a member of :

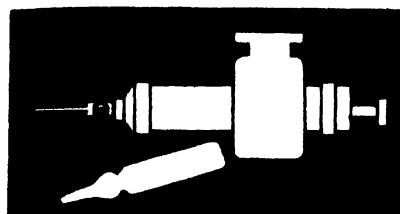
1. Comité Internationale des Science Historique ;
2. Commission of International Economic History Association ;
3. International Studies Conference, 1946 ;
4. Anglo-American Historians Conference, 1957 ;
5. First Asian History Congress, 1961 ;



Prof. Nurul Hasan

6. International Congress of Orientalists, 1964 ;
7. International Economic History Conference, 1965; and
8. International Congress of Historical Sciences, 1965.

Prof. Hasan has represented India on several delegations visiting abroad; notably—Indian Delegation to UN General Assembly, 1967 and 1971 and Inter-Parliamentary Conference, 1967. He has been leader, Indian Delegation to the International Congress of Orientalists, Canberra, 1971; Indian Delegation to UNESCO General Conference, 1972 and 1974. He is Fellow, Royal Historical Society, London and Royal Asiatic Society, London.



## MEDICAL NOTES

### Antacids

**A**NTACIDS are those chemical compounds which reduce the acidity of gastric contents. They usually act locally and cannot inhibit the activity of the oxyntic cells (acid-secreting cells) in stomach. Their efficacy depends on their total acid-combining capacity and their action is limited so long as they remain in the stomach. As soon as the antacid is discontinued, its effect also disappears.

These antacids are usually used in the treatment of symptoms (to relieve pain) of various gastric and duodenal diseases, viz., peptic ulcer, gastritis, etc. It is suggested that antacids decrease the stimulation of afferent nerve endings thus relieve pain by neutralizing the acidity of gastric contents. However, the knowledge about whether they can heal the peptic ulcer or affect the course of the disease and the possibility of relapse is still scanty and contradictory.

A large number of compounds are nowadays known possessing antacid property. They are calcium carbonate, aluminium hydroxide, basic aluminium carbonate, etc. Apart from these dihydroxy aluminium aminoacetate, polyamine methylene resin, sodium carboxy methyl cellulose, gastric mucin and other newly synthesized compounds have been also reported to be effective as antacids. These antacids are not free from adverse side effects. Some of them

might have prolonged neutralizing effect but produce constipation and diarrhoea when ingested while others are found reabsorbed, interfere with the process of digestion and are responsible for ionic imbalances.

Considering calcium carbonate as antacid, one should note that calcium present in calcium carbonate is partially absorbed systemically when administered and may be excreted in large amount through urine. This, in turn, increases the pH of urine. Further, it is the calcium ion which is responsible for constipation.

Likewise, antacids containing aluminium may also exert constipating action. In addition, with aluminium it can increase phosphate excretion in faeces diminishing the phosphate available for intestinal reabsorption. In this way, aluminium containing antacids are important in reducing the concentration and precipitation of urinary phosphates in those patients susceptible to the formation of phosphatic calculi. In renal insufficiency, this group of antacids are also helpful in controlling blood phosphate level.

When different salts of magnesium (magnesium oxide, magnesium hydroxide, magnesium silicate) are used as antacids, they produce marked laxative effects. Further, magnesium and silica are found absorbed significantly.

Though some authors suggested gastric mucin, polyamine methyl resin having effective antacid property, their clinical efficacy is claimed only after doing few experiments. More systematic studies are awaited for understanding their actual clinical significance.

In conclusion, it can be stated that in recent days in order to avoid the undesirable side effects of antacids, sometimes use of mixed antacids is advocated in therapy but this also leads to the production of constipation and diarrhoea. All these points suggest that one should be cautious at the time of taking antacids frequently.

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### Aspirin can prevent heart attacks and strokes

**A**SPIRIN, chemically known as acetyl salicylic acid, was discovered in the middle of the nineteenth century and has been in use for a long time as a popular remedy for headache and as a medication to reduce fever. It is one of the safest and most easily available drugs. It does not cost much. It is also used in the treatment of rheumatoid arthritis and other arthritic disorders. Recently as a pain-killer, superior to certain narcotics like codein, when taken orally against the agony of

abdominal cancer, has drawn a good deal of attention in medical science. Its latest use as a medicine to fight heart attacks and strokes has drawn fresh attention.

Heart attacks and strokes, the most dreadful diseases of mankind, are usually caused by blood-clots in the blood vessels occurring in heart or brain respectively. Hundreds of medicines have been tried all over the world to find a successful medication against them. Aspirin is the result of such an in-

investigation which holds promise to bring these dangerous diseases under control.

Aspirin is anticoagulant and keeps blood flowing inside arteries and veins smoothly and clot-free. That is how this simple drug is able to fight the dreadful disease. One aspirin pill a day may prevent heart attacks and strokes and fatal blood-clots and check many circulatory diseases. Aspirin also makes artificial heart valves safe and helps in the fight against cancer and some kidney diseases, particularly problems on account of kidney transplant. It also cures some blood disorders.

Nearly a couple of decades ago, a Californian physician L. L. Craven of Glendale, first observed in 1953 the miraculous property of aspirin in preventing formation of blood-clots which cause heart attacks and strokes. He tried his experiments on nearly 8000 men and not one suffered from heart attack or stroke due to blood-clot. But Craven's work could not attract the attention of the medical world to the efficacy of aspirin for a long time. In 1974, when a medical group in Cardiff, Wales (U.K.) gave 1200 heart-attack patients a single dose of aspirin daily and reduced the mortality to 12% in six months trial and 25% in one year trial, the medical world became aware of the curative potentiality of aspirin. Similarly a Boston group carried out trials on heart attacks and strokes with aspirin in 9000 patients in eight hospitals in four different countries and on an additional 25,000 patients admitted to twentyfour hospitals of Boston area. From such exhaustive trials, the team concluded that aspirin protects from many diseases.

Sidney Cobb of Harvard School of Public Health (U.S.A.) has since 1953 treated 600 patients of rheumatoid arthritis for ten years with heavy aspirin dosage. He has observed that only 4% of the patients died of heart attacks as compared to 31%

of general population and 2% died of strokes as compared to 11% of general population in U.S.A. Aspirin in this way has justified the jocular medical folklore that one way of having long life is to have rheumatism.

Lee Wood of California City of Hope Medical Centre wrote in *Lancet* about the efficiency of aspirin in fighting heart attacks and strokes and inhibiting the growth of circulatory diseases.

Formation of blood-clots is a dangerous symptom and aspirin is able to dissolve such blood-clots in a human body successfully. According to Harvey J. Weiss, Director of Hematology at New York Roosevelt Hospital aspirin acts by blocking the release of chemicals from the platelets of the blood which cause them to aggregate or clot.

The importance of aspirin in curing circulatory diseases got good publicity just a few years back when an American woman in her sixties came to the University of Colorado Medical Centre for treatment. She suffered from the attack of flashing light in one eye upto 150 times a day and also temporary blindness. Doctors call this condition *amaurosis fugax* which is due to blood-clottings passing through retinal blood vessels. She was prescribed aspirin and was cured. When she stopped taking medicine, the disease relapsed and was again cured on continuation. Similarly another woman of 67 years of age came to the London Institute

of Neurology recently who had lost her vision temporarily in the right eye for nearly one and half hour recurring after every two days. She was free of this trouble when she was prescribed aspirin.

In case of thrombocythaemia and Raynauds syndrome, in which the number of platelets of the blood increase vastly causing considerable pain in the fingers and toes due to spontaneous aggregation of platelets and clottings, aspirin medication gave excellent response.

Besides, combination of aspirin with other medications has given great relief to patients in case of ailments arising out of artificial heart valve. Their greatest danger is blood clot causing stroke as the clots form on the plastic or metal valves are broken off and pass through blood stream and enter the brain blood vessel and lodge there. Such a combination medication has been significantly helpful in many types of kidney transplantation disorders.

But one should be cautious in taking aspirin. It is not to be used by patients undergoing operation as it prolongs bleeding time. Edwin W. Salzman, Harvard Professor of Surgery has warned that aspirin should be used with caution as it may cause haemorrhagic disorders and otherwise a simple and straight forward operation.

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## Diphtheria toxin

UNTIL a suitable vaccine was developed, an acute infectious disease caused by a bacillus *Corynebacterium diphtheriae* was one of the dread diseases of children. Today

the disease occurs throughout the world. In recent years morbidity and mortality rates have shown as significant decline and majority of severe and fatal cases occur among unimmunized children.

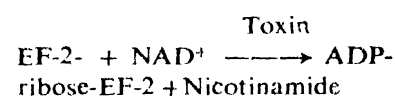
munized children. Although a diphtheria-like disease was described by medical writers as early as the second century A.D., diphtheria was first established as a clinical entity by the publication of Pierre Bretonneau's monograph in 1826. In 1883 Klebs described this bacillus from the false diphtheritic membrane. An year later in 1884 Löffler first isolated the organism in pure culture from the throat of diphtheria patient and demonstrated its etiologic relationship to the disease. Roux and Yersin (1884-1894) discovered and described extracellular toxin and clarified the pathogenesis of the disease. Emil Von Behring (1890) first studied the immunological aspects and produced effective antitoxin. Bela Schick of Vienna was successful in finding out a method for detecting the susceptibility of individuals to diphtheria. In 1913, he introduced his skin test for determining susceptibility. The method was successful in the way that only susceptible children could be actively immunized by toxin-antitoxin mixture. Ramon in 1923 demonstrated that formalin-treated toxin, i.e., toxoid represented a non-toxic, antigenically effective immunizing agent.

*C. diphtheriae* is essentially an obligate parasite of man, hence, the human host represents the only significant reservoir of diphtheritic infections. The organism may be transmitted directly or indirectly from person to person and the disease may spread either directly by droplets, which is probably the most common method of spread, or indirectly by fomites or by a carrier. The organisms are present in the mouth or nostril and are expelled by sneezing, coughing but may also spread by spitting or kissing. Contamination of the hands, handkerchiefs also play an important role.

The usual habitat of the diphtheria bacillus is the upper respiratory tract of man. The primary lesion is usually located in the pharyngeal

area (fauces, nasopharynx or larynx). Thus diphtheria is an acute, febrile infection, generally of nose, throat and tonsils. The throat becomes considerably inflamed especially fauces, where a greyish false membrane is formed. The membrane may eventually spread to the entire respiratory tract. Children between 2 to 5 years are frequently affected. The organism is present in the false membrane in cases of diphtheria and in the throat and nose of healthy carriers, or in local lesions. From a convalescent or a healthy carrier, the virulent organism gains entrance to the upper respiratory tract and the organisms multiply, thereby producing a false membrane. The organism elaborates a specific soluble exotoxin diphtheria toxin which is responsible for the local cellular injury and the systemic manifestations of the disease. The absorption of this toxin by neighbouring cells initiates a process of tissue necrosis, which furnishes conditions favourable to the growth of the organism, which, in turn, produce more of toxin. As the process continues, it stimulates an inflammatory reaction on the part of body, leading to the formation of the typical diphtheritic membrane. The bacterium produces the toxin only when infected by a temperate bacteriophage carrying *tox* gene and when the inorganic iron of the surroundings has been largely depleted. If the membrane involves the larynx and trachea, mechanical obstruction to the airway may develop and death owing to suffocation may occur unless the oxygen lack is corrected by intubation or tracheotomy. Despite the fact the bacteria caused only superficial membranous lesions in the throat, the patient often dies with evident damage to many organs. The toxin elaborated by the organisms produces an injurious action on the kidneys and muscles of the heart. Injury to the heart is probably the most important action of the toxin.

Chemically diphtheria toxin is a complex protein. The mechanism of its action remains unclear, although when applied to susceptible mammalian cells grown in tissue culture, it inhibits protein synthesis. The diphtheria toxin is actually an enzyme that catalyzes a reaction between  $\text{NAD}^+$  and elongation factor EF-2 required for translocation in mammalian ribosomes and by inactivation of elongation factor EF-2 the toxin blocks incorporation of amino acids into proteins. The toxin transfers an ADP-ribosyl group from  $\text{NAD}^+$  to EF-2 to yield an inactive ADP-ribose-EF-2 complex, resulting in inhibition of translocation.



A concentration of the toxin in the cytoplasm of only  $10^{-8}\text{M}$  is sufficient to promote the fatal reaction. Now question arises how does this toxin enter a cell? It has been observed that part of protein toxin contains a special structure that binds at discrete sites on the cell membranes and binding at these sites stimulates pinocytosis (cell drinking process). It has been reported that in toxic diphtheria, there is a loss of glycogen from the liver in the first week of the disease. The production of insulin is ceased which causes hyperglycaemia (increased blood glucose level) followed by hypoglycaemia (decreased blood glucose level). Diminished excretion of vitamin C in urine is a marked feature. Bleeding and coagulation time are increased in cases of diphtheria.

The prompt administration of diphtheria antitoxin which neutralises the circulating toxin in adequate amounts is the first and most important step for treatment. As the antitoxin is a foreign protein (horse serum), precautions should be observed against the occurrence of hypersensitivity reactions. Active im-

(Continued on page 112)



## Love-play in animals

**L**OVE-play is an important part of animal reproduction. This helps in recognition of the species by mates. Mating brings the two partners close to each other. As some animals are predatory in nature, they avoid to come in contact with each other, afraid of being hurt or killed in the process. This avoidance is an adaptation against predators. Since the females are in a much delicate position, they need an elaborate love play by the males for participation in the mating.

In some animals it is the female which persuades the male for the purpose. The male peacock dances with beautiful feathers in front of the female in the breeding season to encourage her for mating. The males of domestic pigeon and house sparrow also dance before their females for the purpose. The dance is specific for each species. Females readily accept only those males who punctiliously observe courtship behaviour characteristic of their species. In

a colony of honeybee, the Queen takes her first aerial flight followed by a number of drone bees. She

mates with one drone in the mid air. The genital parts of the male are forced out with such a great pressure that he dies after mating. In sea horses (*Hippocampus*) the male and female dance and embrace each other several times. During this process the female lays eggs in the brood pouch of the male who takes care of them.

A fish called Drago net (*Cellionymus*) shows an elaborate courtship. The male rushes in a state of great excitement, frightening the other males in the vicinity. He, then, swims around the female with all his fins erect displaying different colours. Finally, the male lifts his mate by placing his pelvic fin beneath her. The two fishes then swim vertically downwards towards the bottom. In Bitterlings (*Rhodeus amarus*) the female is at first attacked by the male. She either withdraws quietly or merely avoids the attack by swimming

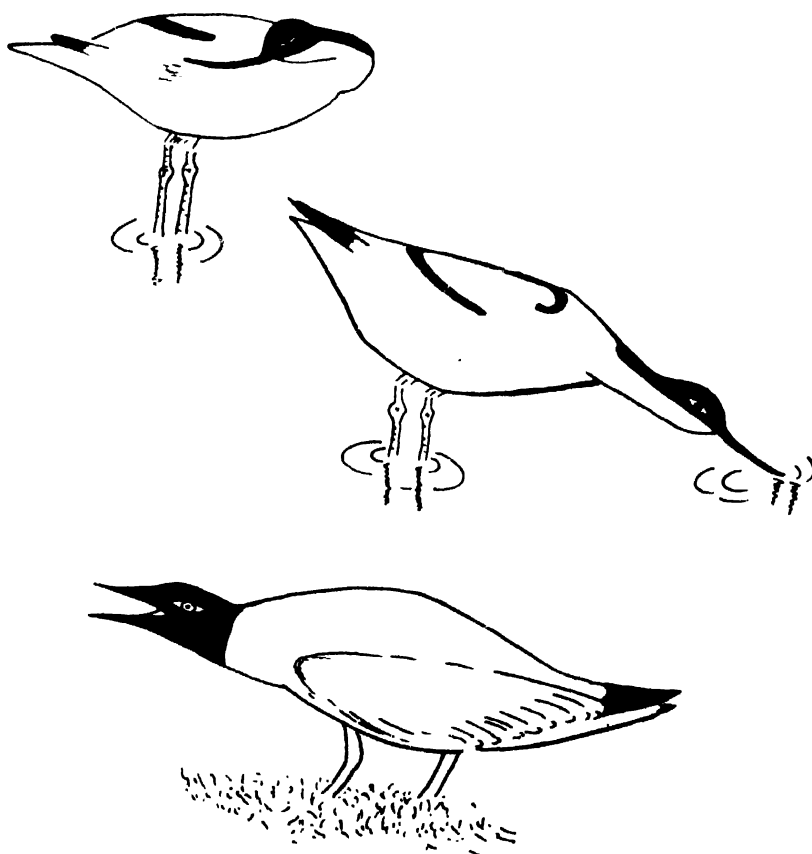


Fig. 1. Courtship display of European avocets (top); The forward threat-posture of black-headed gull (bottom)

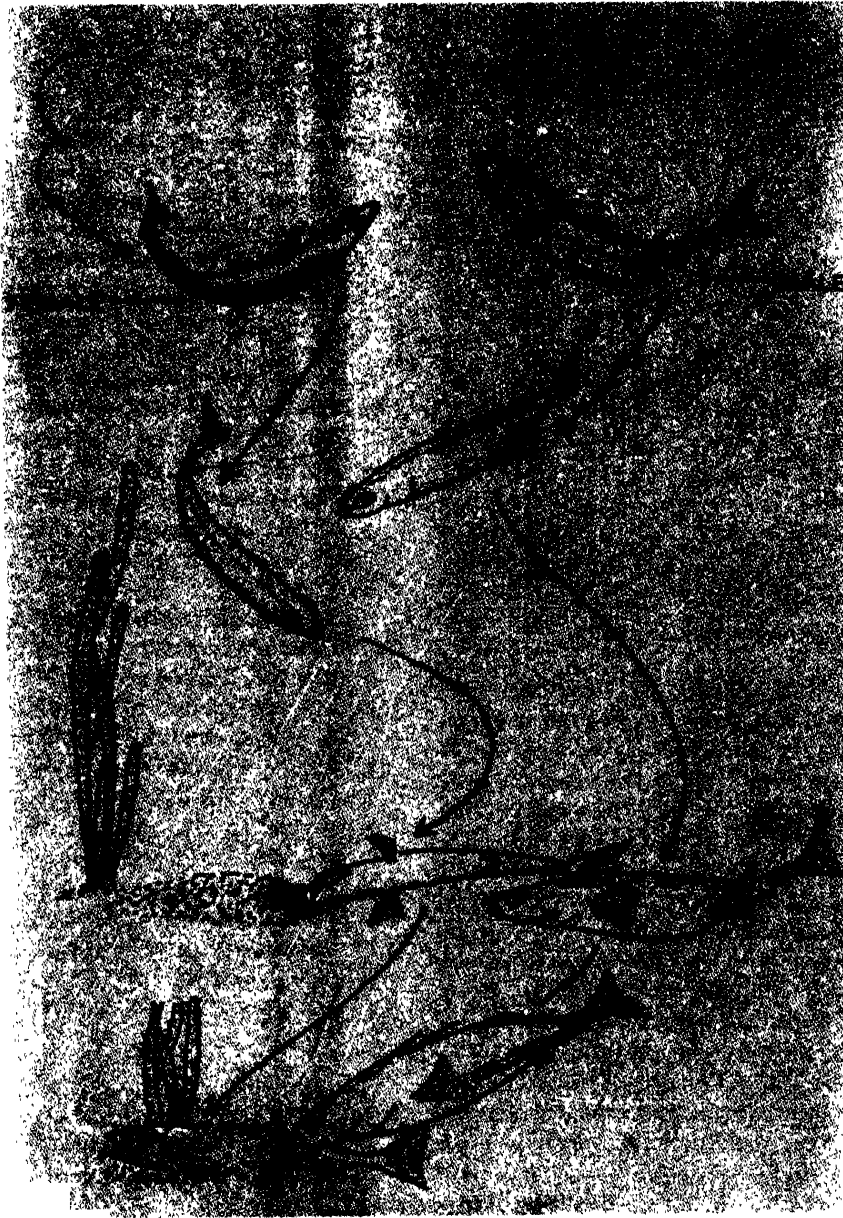


Fig. 2. Courtship sequence of three-spined stickleback

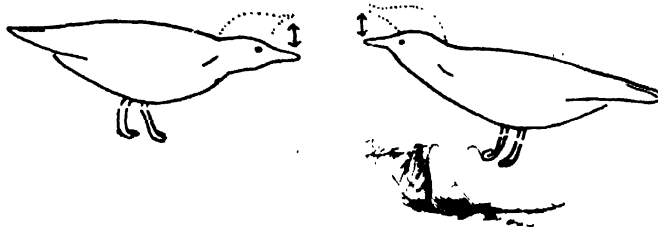


Fig. 3. Courtship display of herring gulls

under the male. The male then seems unable to attack her. After a while he ceases to try and courts the female.

In three-spined stickle-backs (a fish), the male constructs the nest with the treads of algae at the bottom. After constructing the nest, the male becomes dark red coloured on the abdomen and his eyes become brilliant. He looks extremely attractive in this conspicuous dress. He parades up and down his territory till a school of females approaches it. The females by this time have developed a brilliant silvery gloss and swollen body with bulky eggs. The male reacts to them by performing a curious dance towards and all around them. Each dance consists of a series of leaps during which the male first turns as if going to swim away from females, then abruptly turns towards them with its mouth wide open. Usually it stops in front of the female and then turns away for a new performance. This zigzag dance frightens most of the females but a single one may be attracted. She turns towards the male and adopts a more or less upright position. The male now swims hurriedly towards the nest followed by the female. The male shows the entrance of the nest to the female and she enters into it. The male now begins to prod her tail base with his snout, giving series of quick thrusts. After some time she lays eggs. The male fertilizes the eggs and takes care of them and young ones.

Birds exhibit an elaborate courtship behaviour. In Wilson's Phalaropes, the female selects a male and swims around him. When another female approaches the pair, she threatens and at times fights to ward off the intruder. Before the pair mates, they face each other with their heads raised, the bill of each bird aimed at a point above the other's head. Since the Phalarope threatens and fights with its beak, the posture signifies that no threat is intended. The female then shows readiness for



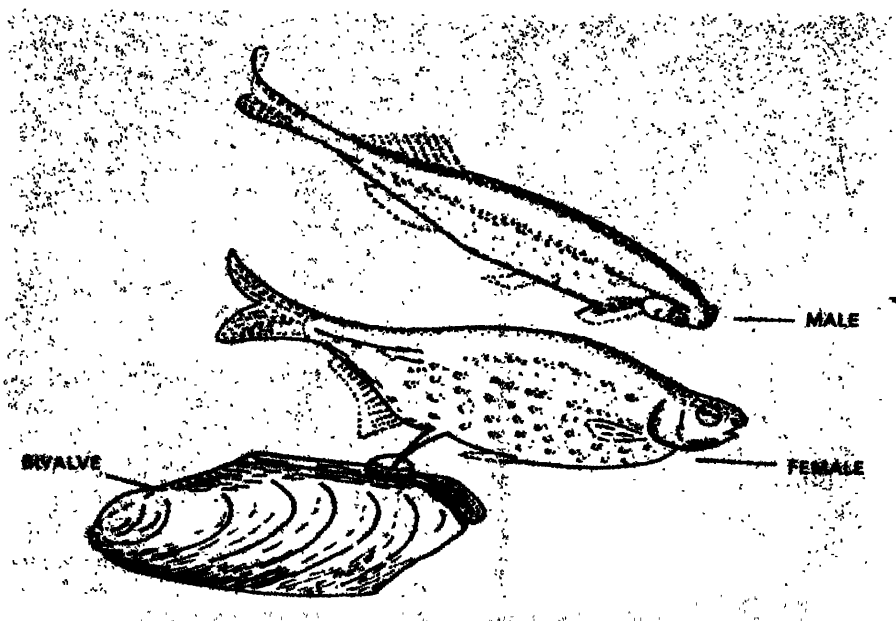


Fig. 4. Male bitterling courting the female during spawning

mating by taking a crouching position. The males develop brood pouch on the abdomen and incubate the eggs.

In Avocets (a type of bird), the male and female stand and preen their feather in a hasty, nervous fashion. After sometime the female stops preening and adopts a flat attitude. This is the signal indicating her willingness to mate. In Herring Gulls, both male and female bob their heads upwards uttering a soft melodious call with each bob. After a series of such calls the male takes the initiative for mating. In Ruffs (*Phalacrocorax pugnax*), the males lift their wings for attracting the female flying at a distance. When the Black headed Gulls (*Larus ridibundus*) meet in the breeding season, they show a

forward display by lowering their heads and pointing the beak towards each other. This threat posture is emphasised by brown face which surrounds the bill. Males, however, show their friendly intentions by "head flagging". They stretch the neck and then by a sudden jerky movement turn their faces away from each other. Here the male appeases the female and vice versa as both of them are aggressive.

In some web-building spiders, the male visits the female on her web. Here the male appeases the female because he might be mistaken for a prey.

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## Science quiz

THE quiz given here deals with some aspect of science. The reader is required to fill up the blanks

in the statements given below with appropriate words. With the answers arranged in the same sequence as the

statements, the first letters of the answers will read "Council of Scientific and Industrial Research".

### Group A

- (1) Science of secret of communication is known as—.
- (2) Life on earth is protected from the biologically harmful ultra-violet radiations emanating from the sun by the—layer in the atmosphere.
- (3) The largest magneto-hydrodynamic power station in the world is situated in the—.
- (4) The fourth atomic power station in our country is located at—in Uttar Pradesh.
- (5) The 1978 Nobel prize for—was awarded to Professor Peter Dennis Mitchell (England) for his work in bioenergetics.
- (6) On a hazy day clear photographs can be taken by using films sensitive to—radiations.
- (7) —year is the distance travelled by light in one year.
- (8) Mirage is an—illusion.
- (9) Power systems in our country are operating at a frequency of—hertz.

### Group B

- (10) —is the name of the Franco-German communications satellite which is being used by India.
- (11) A blotting paper soaks up spilt ink due to—action in the pores of the paper.
- (12) —of an element have the same chemical properties but different masses.
- (13) —velocity is the minimum velocity with which a body must be projected to make it escape from the gravitational pull of a planet.
- (14) Deficiency of vitamin A causes —(a kind of blindness).

- (15) 'STEP' stands for Satellite ——— Experiment Project.
- (16) The layer of charged particles surrounding the earth which facilitates long distance transmission of short radio waves is known as the——.
- (17) —— are a class of magnetic materials which are used as transformer cores at very high frequencies.
- (18) The principle of a pressure cooker is the elevation of the boiling point of water with the —— of pressure.
- (19) Neutron is an electrically neutral particle discovered by——.
- (20) Vienna is the headquarters of the International——Energy Agency.
- (21) The alloy—— is commonly used to make the heating element of electric heaters.
- (22) The apparent change in frequency of sound due to relative motion between the source and the listener is called the —— effect.
- (29) Radium is a —— element.
- (30) —— is the property of matter by which it continues to remain in its state of rest or uniform motion in a straight line, unless that state is changed by an external force.
- (31) A camera lens looks coloured due to—— coating on the surface of the lens which reduces reflection losses.
- (32) —— is produced due to the amplification of electromagnetic waves by stimulated emission of radiation. It operates in the infrared and optical regions.
- (35) Germanium is an—— which has found extensive applications in the production of transistors.
- (36) —— is a day on which the day time and the night time are of equal duration.
- (37) Penicillin is an——.
- (38) Mach number is the—— of the speed of an aircraft to the speed of sound in air.
- (39) —— is the unit for measuring the quantity of electricity in the S.I. system.
- (40) In a nuclear fission power reactor—— water functions as a moderator.

## Group D

- (33) —— discovered X-rays.
- (34) —— is the science related to the study of extra-terrestrial life.

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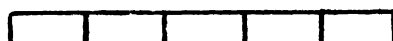
## Group C

A traveller who goes west, across the 180 meridian loses a day, when he travels east he gains a day. This meridian is called the——date-line.

- (24) National Environmental Engineering Research Institute is located at——.
- Niels Bohr, a—— physicist first applied the quantum theory to build up an atom model.
- (26) —— radiation emitted by the mercury vapour inside a fluorescent tube during electric discharge, is converted into visible light by the fluorescent substance coated on the inner surface of the tube.
- (27) The outermost planet visible to the naked eye is——.
- (28) —— is an explosive obtained by the nitration of toluene.

## 1. Flower pots

Twentyfive flower pots have to be placed in the square spaces shown in Fig. 1. The pots contain flowers of five distinct varieties, and so five pots belong to every variety. The problem is to place the pots in such a

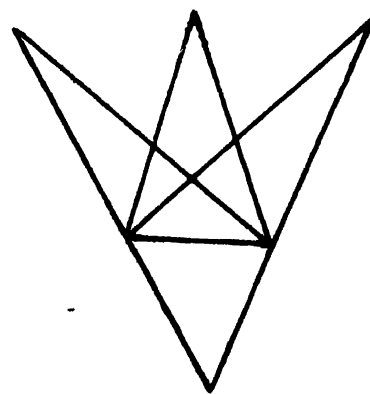


Fig

way that no two pots containing flowers of the same variety appear in any line vertically, horizontally or diagonally.

## 2. Can you count ?

Can you count the number of triangles in Figs. 2, 3 and 4; and the



Fig

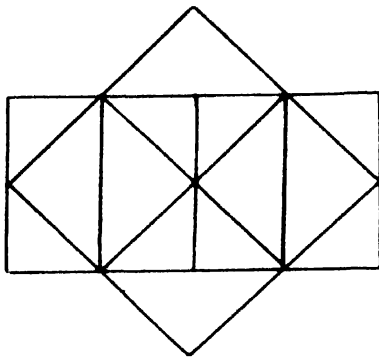


Fig. 3

number of quadrangles in Figs. 3 and 4. Remember the quadrangles include squares and rectangles too.

### 3. Dissecting the square

Can you divide a square into twenty equal right-angled triangles and then arrange them to form five equal squares?

### 4. The daughter's age

Jai Gopal has an only daughter Kamini. He is very fond of her. The

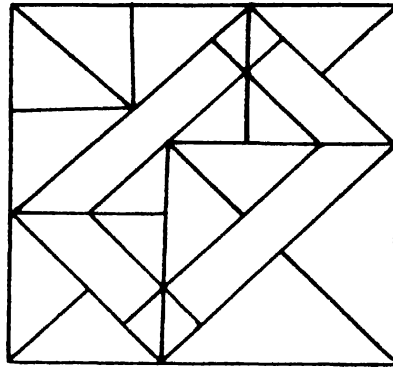


Fig. 4

other day when he was having coffee with his friend, the latter remarked, "Your daughter Kamini is a fine girl. How old is she now?" "Her age", said Jai Gopal, "is given by reversing the figures of my own age. In ten years I shall be exactly twice as old as she will then be." Can you guess how old is Jai Gopal's daughter?

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## Latest on animals and birds

### Squirrels are cannibals

IT is very hard to believe that such a gentle and innocent-looking creature like squirrel not only kills but also eats the infants of its neighbours. This is true in the case of Belding's ground squirrel found in Sierra Mountains of the U.S.A. (*Nature*, 18 Oct., 1979). The killer is invariably a young male or an adult female. The young male eats the infant as it is rich in protein, which is useful for body growth. The adult female, on the other hand, only kills the infants when its own baby dies. By killing the baby the female removes a future competitor for food and other things.

The killing of infants in this manner is a part of the normal day-to-day life of the animal. About eight per cent of infants of this animal die in this manner. The adult females are, however, nice to their close relatives' babies and warn them of any danger, even sometimes risking their own life. The Belding's ground squirrels also hibernate, that is, they sleep through eight months of the year under the snow-covered ground. A large number of them die during hibernation.

### Ostrich is selfish

OSTRICH, the world's largest living bird, is as selfish as human

beings. The selfish tendency is particularly evident in the breeding season. In an ostrich society, a male ostrich has a harem of two to seven hens. The hens, each of which can lay upto 13 eggs in one season, lay their eggs in one common nest. Only one of the hens in the harem, called the major hen, hatches the eggs, but she can hatch only about 20 eggs. Often, the total number of eggs laid is more than the number of eggs that can be hatched. The major hen therefore throws away the excess eggs. While throwing away the excess eggs the major hen is careful enough not to throw away any of its own eggs (*Nature*, 17 May, 1979), and also keeps a small number of other hens' eggs, so that the total number of eggs in the nest is about 20. The major hen seems to distinguish her eggs from the eggs of other hens by their shape and size. The major hen does not show partiality to any of the other hens while keeping their eggs along with its own eggs for hatching. The reason for keeping a small number of other hens' eggs is that by doing so the chance of her chick being killed by any predator is minimised.

### Green polar bears

HAVE you ever heard of, if not seen, a green bear? San Deigo Zoo in the U.S.A. is one of the many zoos where the coat colour of the polar bears has changed from snowy white to green (*Nature*, 29 March, 1979). The green colouration is found to have been caused by a harmless algae growth inside the hairs of the coat. The algae growth is possible only at a temperature around 36°C. Polar bears, therefore, do not change their coat colour in their natural habitat—the arctic region—, where the temperature is below 0°C all around the year. The chest and the inside of the legs do not become green because these parts of the body are not exposed to sun. A number of other animals such as water turtles,

monk seals, fur seals, sloths and several kinds of whales also change their colour in a similar way.

### Precocious jackals

**A**T least in one way, young jackals are different from the young of many other animals. They help their parents. Even though the young jackal is capable of living independently

on its own when it is a few months old, it chooses to stay with its parents for a year or two (*Nature*, 1 Jan., 1979). During this time if the mother of the young jackal gives birth to new ones, the young jackal helps her in bringing up the new cubs. But not all the youngsters stay with their mothers to help them in bringing up the new cubs. The older the mothers are,

greater is the chance of the youngster staying with them and helping them. More cubs survive if there is a helper in the family because the helper guards and feeds the cubs when their mothers go out to hunt for food. Sometimes there are more than one helper at a time in a family.

P. SUNDERARAJAN

## PHYSICS OF CANDIDATE EVALUATION (Continued from page 87)

Extending the ideas of the principle of indeterminacy to general four-dimensional space-time, we have to replace fixed point by a fixed surface. In this situation the energy-time uncertainty relation becomes: the uncertainty in the instant when a particle with energy uncertainty  $\Delta E$  crosses the fixed surface is such that the product  $\Delta t \cdot \Delta E$  is larger than the constant of action. The forementioned surface may be closed around a three-dimensional domain of finite volume. Then the information about the time at which the particle crosses into this domain is governed by the above statement. But the problem of an ingoing particle is like looking for solution for the Schrodinger equation under given initial conditions and under some boundary conditions. These two sets of conditions have to be consistent with the position-momentum and energy-time uncertainty relations respectively, and the procedure involved is the same as one adopts in the theory of scatter-

ing. A natural inference of this is that for comparative study of different systems or particles, the conditions must be same for all of them.

In the context of the problem being discussed here, the higher class, position or job may be taken as the domain with qualifications and selection criteria as the initial and boundary conditions. To give equal chance to all the candidates to make a way into the domain, these conditions should be identical for all of them. This can be achieved if the experts (who are certainly free to define the constraints) are unbiased and equally disposed to all the candidates. In other words, the attitude and questioning during evaluation should be without any predilection.

The above discussion leads us to conclude that the examinations and interviews can be made true judge of knowledge and capability under following conditions:

1. The questions should be chosen properly and their level

kept same for all the candidates. 2. The examiners should not put the questions in a humiliating manner; instead they should be equally modest to all the candidates. 3. The candidates should preserve their equipoise and evolve their personality to face all situations. 4. The time of interview/examination should be sufficiently large and same for all the candidates. 5. The experts should assess all the candidates with same level of stringency and no prejudice.

### Further reading

1. Price, W.C. and Chissick, S.S., *The Uncertainty Principle and Foundations of Quantum Mechanics*, John Wiley, London, 1977.
2. Gamow, G., *Mr. Tompkins, in Wonder Land*: Cambridge University Press, 1957.
3. Vishwamittar, *The Principle of Uncertainty*, *Science Reporter* 7, 111-115 (1970).

## TECHNOLOGY FOR VILLAGES (Continued from page 139)

a scraper attached to the stirrer removes the ash through holes at the bottom. The ash falls in a conical hopper and is removed through a porthole. A third blower supplying secondary air suppresses flame from touching the heat exchanger tubes.

The fourth and the main blower draws in hot air from the heat exchanger and delivers it to the dryer through ducts. The unit ensures 100 per cent burning of the husk inside the combustor. The ash can be used as fertilizer, and for production of

cement and other potential applications. The technique also completely eliminates the chance of sulphur contamination of rice, which normally occurs with furnace oil fired-drying.

# SCIENCE FOR THE YOUNG

## Answers and solutions

### Science quiz

#### Group A

- (1) Cryptography
- (2) Ozone
- (3) U.S.S.R
- (4) Narora
- (5) Chemistry
- (6) Infrared
- (7) Light
- (8) Optical
- (9) Fifty

#### Group B

- (10) Symphonie
- (11) Capillary
- (12) Isotopes
- (13) Escape
- (14) Nightblindness
- (15) Telecommunications
- (16) Ionosphere
- (17) Ferrites
- (18) Increase
- (19) Chadwick
- (20) Atomic

(21) Nichrome

(22) Doppler

#### Group C

- (23) International
- (24) Nagpur
- (25) Danish
- (26) Ultraviolet
- (27) Saturn
- (28) Trinitrotoluene
- (29) Radioactive
- (30) Inertia
- (31) Antireflection
- (32) Laser

#### Group D

- (33) Roentgen
- (34) Exobiology
- (35) Semiconductor
- (36) Equinox
- (37) Antibiotic
- (38) Ratio
- (39) Coulomb
- (40) Heavy

A	C	B	E	D
C	E	D	B	A
D	B	C	A	E
B	A	E	D	C
E	D	A	C	B

Fig. 5

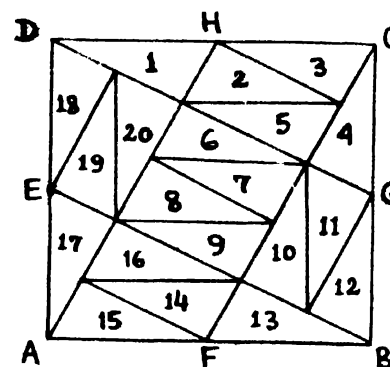


Fig. 6

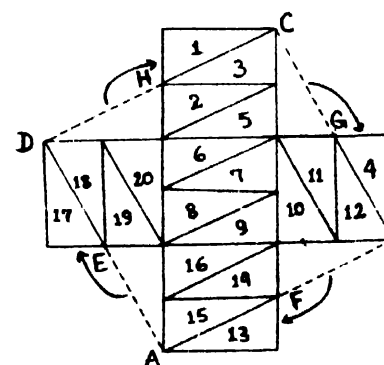


Fig. 7

where  $m=0, 1, 2, \dots$

from (3) and (4)

$$y = 6 + 19m \quad \dots(5)$$

The only value of  $m$  giving plausible solutions for  $x$  and  $y$  is  $m=0$ . So  $x$  is 2 and  $y$  is 6. The age of Jai Gopal's daughter is therefore 26.

### Brain teasers

1. The solution is shown in Fig. 5. Flowers of different varieties are indicated by the letters A, B, C, D and E.
2. There are eighteen, twenty and twenty-nine triangles, respectively in Figs. 2, 3 and 4. The number of quadrangles in Figs. 3 and 4 are nineteen and eleven respectively.
3. The way how to dissect the square into twenty right-angled triangles is illustrated in Fig. 6. In the diagram F, G, H and E are the mid points of the four sides of the square. These triangles are finally arranged in Fig. 7 to form five equal squares. The diagrams are

self explanatory.

4. Call the units-digit and the tens-digit of Jai Gopal's age  $x$  and  $y$  respectively. So, his age is  $10y+x$ ; his daughter's age is  $10x+y$ . After ten years,

$$10y+x+10=2(10x+y+10) \quad \dots(1)$$

whence we get

$$8y-19x=10 \quad \dots(2)$$

which on rearrangement gives

$$y = (19x+10)/8 \quad \dots(3)$$

As both  $x$  and  $y$  have to be integers, 8 must divide  $19x+10$ . This gives the smallest value of  $x$  as 2. So,  $x$  must be of the form

$$x = 2 + 8m \quad \dots(4)$$



## FOR HER

### Beware of the common germ killers

**C**IVILIZED men and women today tend to be extra-conscious of the microbial population on their skin. No doubt, this is the result of constant reminders about their existence by advertisers and sales promotion personnel for various antimicrobial products. Both antibacterial and antifungal agents now find a place in soaps, handwashes for health-care personnel, antiseptics in the form of powders, ointments, creams, emulsions and liquids for the intact skin and for cleaning and protecting small, superficial skin wounds. How safe are these and how effectively do they do their job are of vital concern at any time.

An advisory panel set up in 1974 by the Food and Drug Administration, U.S.A., has so far cleared only five antimicrobials as safe and effective for cleaning minor skin wounds. They are hexylresorcinol, benzalkonium chloride, benzethonium chloride, methylbenzethonium chloride and poloxamer 188. However, for use in soaps, skin wound protectants, handwashes for nurses and

doctors, surgical hand scrubs and skin antiseptics, these ingredients are stated to be in need of further study to prove their safety and effectiveness.

In regard to iodine, a one-time favourite, the panel has declared it as safe and effective for preoperative skin cleaning, but not for treatment of wounds. This is because in the presence of organic matter such as blood, pus, etc., iodine loses its germicidal power and besides, under certain conditions of use, the tincture may even adversely affect the user. Needless to say, no consumer would like to use it regularly as a skin antiseptic because it stains the skin and clothing.

In 1972, came the tragic news of the death of 30 babies, as a result of applying a baby powder marketed at that time in France. The cause of the deaths was later identified as hexachlorophene. The germicide had penetrated the skin, entered the blood stream and eventually produced brain damage in the children.

Hexachlorophene or G 11 was once acclaimed as a wonder deodorant and germicide. Unlike many other antibacterials, this chlorinated phenol of the diphenyl type was found to retain its bacteriostatic properties even when incorporated in soaps and detergents. The optimum concentration in soap was found to be 2 per cent; carbolic acid or phenol had practically no germicidal activity when present in this concentration in soaps. Besides, it was found that even after rinsing off the soap, the HCP clings to the body surface for several hours, fighting the skin bacteria, especially the Gram positive staphylococci and streptococci responsible for minor skin infections and perspiration malodours.

The baby powder, no doubt, was not expected to contain any germicide but in the process of manufacture it had accidentally got mixed up with HCP, the concentration of which in the powder was later found to be

6 per cent, a dangerously high level for any toilet powder. The incident triggered off a chain reaction, which led to many governments banning the use of HCP as a general antiseptic. India banned the import of HCP. The chemical was taken out of toothpastes, powders and shampoos marketed in India, but not from some soaps.

That the use of HCP in soaps is not safe for all was brought home once again by a study conducted on nurses working in six hospitals in Sweden during the period 1970 to 1976. The study, presented at a recent meeting of the New York Academy of Sciences, highlighted the high incidence of birth defects in infants born to nurses who had regularly used soaps and surgical scrubs containing up to 3 per cent HCP. Out of 460 babies born to nurses who had been using the HCP soaps 10 to 60 times a day for at least the first three months of pregnancy, 25 had serious birth defects ranging from eye disorders to central nervous system abnormalities. By contrast, a control group of 233 babies born to nurses who worked under the same conditions but had not used the HCP soaps, did not show any severe birth malformations. None of the nurses in the study were exposed to anaesthesia gases, because these gases are now strongly suspected to give rise to birth defects.

Another antibacterial about the safety of which experts have serious reservations is triclosan, which is mainly in use in hospitals, nursing homes and other 'closed' environments. The F.D.A. panel has categorised triclosan as unsafe and ineffective for use in hand washes for health-care workers, surgical scrubs, and patient pre-operative applications. According to the panel, triclosan products should never be used on infants under six months of age. This precaution must of course be observed in regard to any non-prescription bacterial formulation.

The message seems to be clear. The safety and efficacy of all antimicrobial products currently marketed, except the skin wound cleansers containing the acceptable ingredients, are in doubt. In fact, the use of medicated soaps and general skin antiseptics is not even called for; normal skin has admirable defences against the onslaught of microorganisms. Even when slightly injured or inflamed, it has remarkable recuperative powers. No medicated product should be used on a child under six months, without the doctor's prescription. This rule also applies to patients at high risk such as burn victims, the old and the infirm. Skin antiseptics, skin-wound

cleansers and protectants should never be used on animal bites and at no time should the period of treatment with these exceed 10 days, unless the doctor approves. To make doctors and consumers aware of the inherent danger in their use, all antimicrobial products should carry adequate labelling. If anyone extols them and projects them as indispensable aids to health and beauty, it could do incalculable harm to the health of many an unwary consumer.

THANKAMMA JACOB  
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Fig. 2. Greying of hair in patches

## Greying of hairs

**W**HEN hair colour changes from black or deep brown to white or yellowish white, it is called greying of hairs and considered a sign of aging.

Greying in scalp hairs usually begins in forties in both the sexes,

however, it may begin at any age. If it begins before the age of twenty it is called premature greying. Sometimes greying is delayed.

It begins first of all at the temples and progresses with time towards crown. Later it spreads to the occipi-

tal region (Fig. 1). The number of grey hairs slowly increases. The beard hairs become grey afterwards and lastly, some of the body hairs also become grey. This sequence of greying can change sometimes. In grey haired individuals, partially pigmented hairs can also be seen.

Hair generates from a pouch-like depression in the skin. Hair is made up of keratin which is synthesized by cells called keratinocytes. Colour of hair is due to a pigment called melanin which is produced by melanocytes. These cells are found in the swollen part of the hair root called bulb.

In the process of greying, there is a gradual decrease in the production of melanin by melanocytes and their number also decreases gradually.

Greying is an inherent character which is determined by genes. In individuals of the same family, there is predisposition to greying. It



Fig. 1. Premature greying of hair in a 17 year-old boy

can appear to occur overnight if pigmented hairs are lost selectively all of a sudden and nonpigmented ones are retained. It can also occur due to gross malnutrition and in certain diseases like pernicious anaemia, hyperthyroidism and progeria. In progeria, old age changes start in childhood. The growth of the child is retarded, the skin becomes wrinkled, scalp hairs grey and fall off. The appearance becomes that of an old man.

Grey hairs can also be seen in patches in diseases like vitiligo and piebaldism (Fig. 2).

Vitiligo is also known as leucoderma. In this skin becomes white in patches which can occur anywhere on the body, and the hairs on those patches also become white sometimes. In piebaldism a bunch of white hairs is present in the frontal region of the scalp and the underlying skin is white since birth along

with white patches on certain other parts of the body.

Greying of human hairs is irreversible. Cosmetic dyeing is the only remedy.

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## LETTERS (Continued from page 77)

of solid materials. The source of this type of aerosols is living organisms such as viruses, bacteria, pollen grains, spores, trichomes (plant hairs) fragments of fungal hyphae, algal cells, filaments, insect scales and miscellaneous materials.

The size of a particular aerosol is directly related to three characters. They are : (i) lung deposition, (ii) chemical activity, and (iii) residence time in the atmosphere.

T. SAMPATH KUMAR

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### Notonecta

Sir, This is in regard to the article 'The insect that swims on its back' by E. S. N. Murty (S.R., May 1979).

The author has reported that *Notonecta*, like other members of family Notonectidae, are also known as 'water boatmen', whereas water-boatmen form an altogether diffe-

rent family, i.e., *Corixidae*. Fig. 1 of the article shows a common Corixid (water boatmen) belonging to the genus *Sigara*. It is found extensively in the Ganga around Varanasi during the present study of the pollution and self-purification of the Ganga at Varanasi.

The Corixids as a group form an important biological indicators of clear unpolluted waters, rich in the dissolved oxygen content and profuse aquatic vegetation.

For further references, following books are suggested: *Fresh water Invertebrates of the United States* by Robert W. Pennack, 1959, and *Immi's General Text Book of Entomology*, Tenth Edition, Vol. 2; *Classification and Biology* by O. W. Richards and R. G. Davies, 1977.

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First para of the article reads "Notonecta, an aquatic insect found in fresh water ponds, lakes, etc., floats like a boat on the surface of water. It is therefore known as 'water boatman'. The insect can also swim...it turns upside down while swimming, i.e., it is a 'back swimmer'."

It is true that *Corixids* are known as 'water boatmen'. 'Water boatman' is only a common name which may also be applied to *Notonectidae*. Please refer to T. T. Macan (1964), *A Guide to Fresh water Invertebrate Animals*, Longmans, Green and Co. Ltd., London W. 1, (p. 111).

The common name "water boatman" is not so specific to *Corixidae*. However, the common name 'back-swimmer' is specific to *Notonecta*.

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Science

## What is spray drying?

**S**PRAY drying is the direct transformation of a slurry, suspension or paste into solid by spraying the feed into a hot drying medium which is usually air. It was first

applied to the dairy and food industry in the latter half of the 19th century, and today it is finding applications in the manufacture of about 200 materials which include catalysts, ceramics, herbicides, pesticides, pigments, dyestuffs, polymers and dessicants besides such common items of daily use like powdered milk, instant coffee, baby food and detergents.

The technique of spray drying stands apart from other conventional methods of drying in terms of end product characteristics, the wide range of moisture in the feed it can handle, and the ease and economics of the operation. It can be operated under perfectly sterile conditions giving bulk tonnage of products.

The spray dried solids are usually fine powders in the form of spheroidal particles with comparatively narrow size distribution. The size range of a few products is given in Table 1. In case of food materials, this is the most suitable technique because the preservation of food quality for a long time is possible by drying under sterile conditions.

**Table 1. Particle size range of spray-dried powders ( $\mu$ )**

Skimmed milk	16-300
Instant coffee	40-750
Pigments and dyestuffs	1.0-50
Whole egg powder	0.8-45
Ceramics	16-750
Silica-alumina cracking catalyst	20-80
Pesticides	0.7-45
Polyvinyl chloride	2.5-80
Detergents	30-1600

**Table 2. Droplet size range by different atomizers ( $\mu$ )**

Pneumatic nozzle	3-300
Vaned disc atomizer	1.2-750
Wheel atomizer	20-900
Pressure nozzle	9-850
Sonic nozzle	1.2-900

**Fig. 1. Schematic diagram of a spray dryer.**  
A-Atomizer, B-Air blower, B<sub>1</sub>-Fine particle blower, CH-Drying chamber, CY-cyclone separator, F-feed, PR-Product solid, S-spray, ST-stack

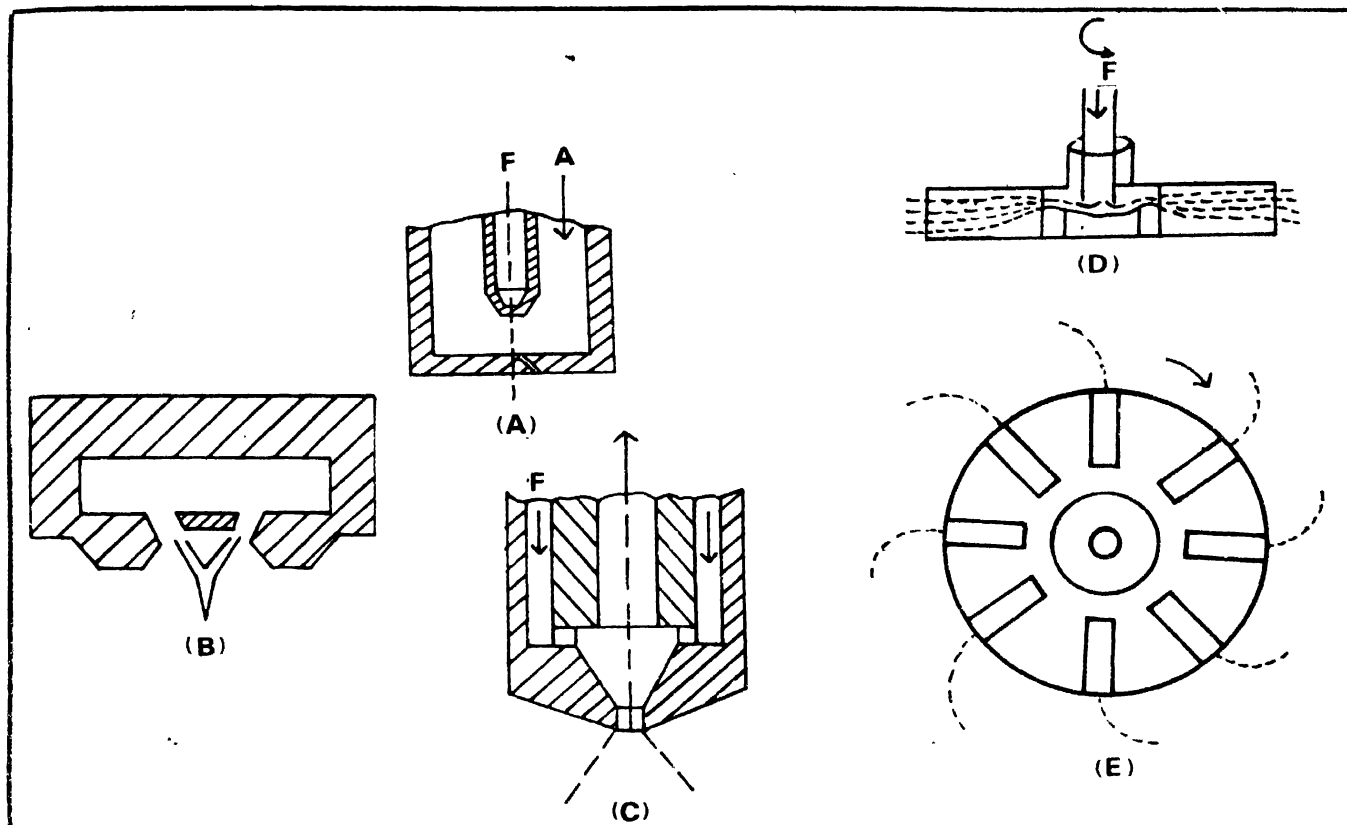


Fig. 2. Nozzles and atomizers; (a) Pneumatic (F-feed, A-air), (b) Pressure nozzle-impinging type, (c) By-pass jet, (d & e) Rotary vaned disc

The lay-out of a typical commercial spray dryer is shown schematically in Fig. 1. The feed containing 25%-96% water by weight (i.e., in the form of a suspension or a thin paste) is sprayed through an atomizer into hot air. In case of skimmed milk, coffee, fruit juice or malt, emulsion or the extract is sprayed. Air is blown into the drying chamber and heated by passing through a heater. The heater may be electri-

cal, oilfired or gas-fired depending upon the energy source, product specifications and dryer capacity. The drying chamber is a cylindrical vessel (90cm-750cm dia.) usually having a conical base. The finely-atomized droplets of spray are intensively dried in contact with the hot air before they strike the chamber wall. The air loses temperature during the process and gains humidity, while the droplets

lose moisture and gain temperature. The final moisture level, particle size and temperature in the dried product are determined by many factors—droplet size, feed rate and its moisture content, flow rate, temperature and relative humidity of inlet air, and dryer dimensions. A part of the dried product (coarser variety) may be collected from the bottom of the conical chamber and the fine dust may be carried pneumatically to a cyclone separator where it is collected. The cyclone separator is a funnel-shaped device where fluid under pressure creates a vortex and the fine particles are sedimented by centrifugation. A part of the product from cyclone separator may again be recycled into chamber. Still finer particles are blown to the stack and collected periodically.

The complete operation of spray drying may be divided into four stages: (a) atomization of feed to

Table 3. Classification of spray on the basis of feed-air contact

Feed entry at	Air entry at	Type of nozzle	Type of spray dryer
Top	Top	Pressure nozzle	Cocurrent
Bottom	Bottom	Rotary atomizer	
Top	Bottom	Pneumatic nozzle	Counter current
Bottom	Top	Pressure nozzle	
Top	Top	Rotary atomizer	Mixed flow
Bottom	Bottom	Pressure nozzle (Fountain type)	
Top	Top	Rotary atomizer	

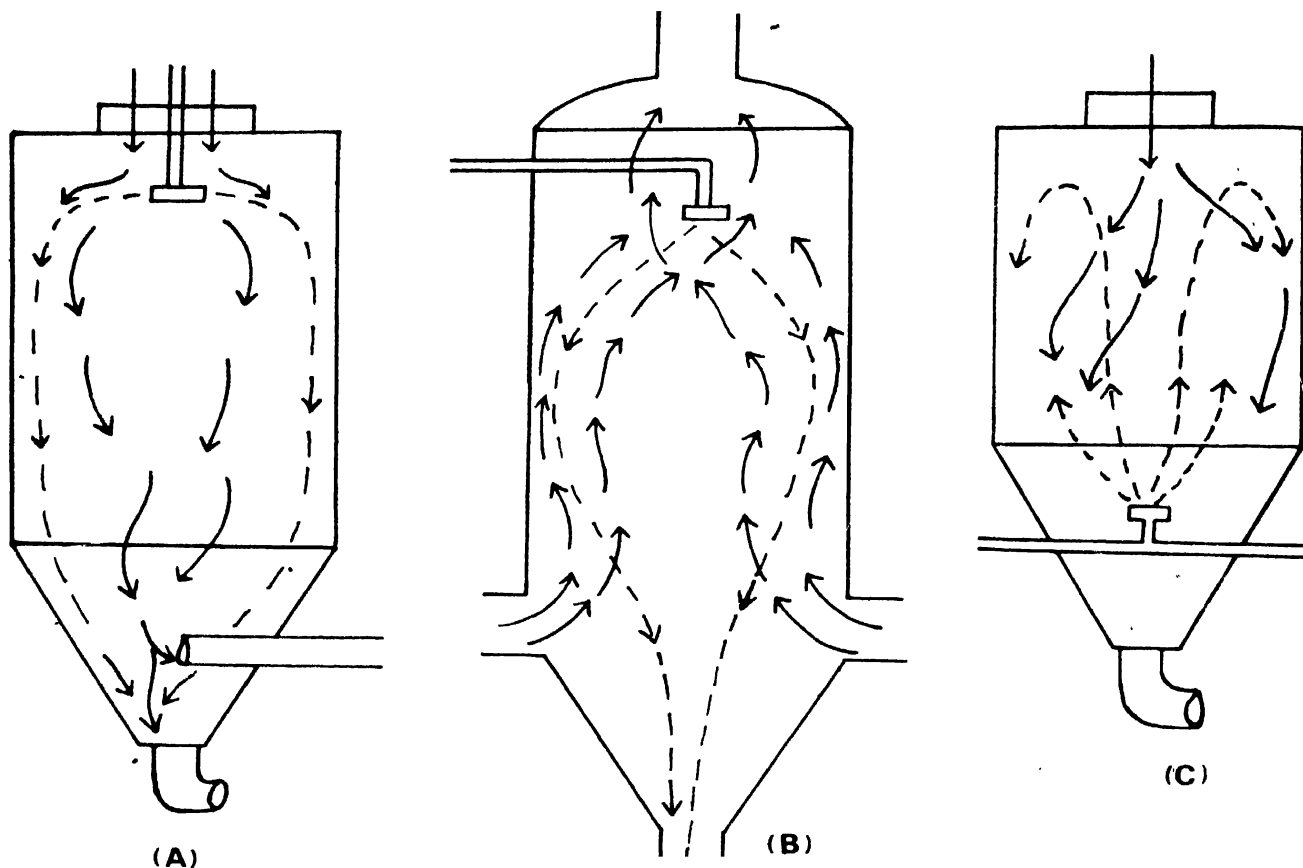


Fig. 3. Classification of spray dryer : (a) Co-current, (b) Counter current, (c) mixed flow (...feed, ---air)

spray, (b) spray-air contact, (c) drying of spray, and (d) separation of dried product from air. Spray dryers vary on the basis of variation in one or more of these stages. However, the most important stage is the mode of atomization which determines the droplet size distribution. There are mainly three ways of atomization: (a) forcing only feed through nozzle under pressure, (b) forcing both air and feed through a nozzle (which is called pneumatic or two-fluid nozzle), and (c) using centrifugal force for shearing the feed into fine droplets (rotary atomizer). Schematic diagrams of some of the nozzles are shown in Fig. 2. Occasionally, in pressure nozzles (two-fluid or single fluid) choking may be a problem. This is eliminated by rotary atomization where a small disc (5cm-20cm dia., simply a wheel

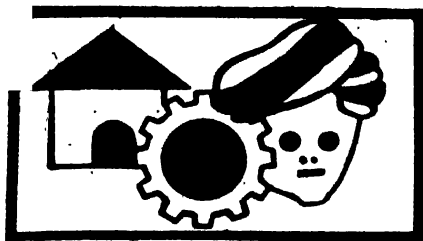
grooved with curved vanes) is rotated at the top of the drying chamber at a speed of 10,000-60,000 r. p. m. and the slurry is fed into it through the top hole. The tremendous shearing force arising out of the centrifugation is responsible for the atomization. Besides these three types of nozzles, another nozzle is also used, that is, sonic nozzle where ultrasonic waves generated by a siren cause very rapid oscillation of the slurry leading to atomization. The droplet size range achieved by each nozzle is given in Table 2.

Depending upon the selection of a particular atomization technique the next two stages, i.e., spray-air contact and the drying of spray are also decided. The classification of spray dryers on the basis of feed and air entry is shown in Table 3.

The economic operation of a

spray dryer is closely associated with drying temperatures and solid content in the feed. The higher the drying temperature and the solid content of the feed, the greater the thermal efficiency of the process. For example, if the exit temperature of air is fixed at 360 K, the increase of inlet air temperature from 410 K to 925 K increases the over-all dryer efficiency from 44% to 70%. Similarly, an increase in feed solids from 50% to 60% reduces the heat load by 50%. For solvent recovery spray dryer may be operated under closed cycle conditions, that is, instead of venting air to atmosphere the same is recycled back after processing.

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## TECHNOLOGY FOR VILLAGES

### Paddy husk combustor developed

**P**ADDY husk so long regarded as a waste, causing storage and disposal problem also, can now be commercially used for drying paddy in rice mills. The Central Mechanical Engineering Research Institute, Durgapur, and the Central Fuel Research Institute, Dhanbad, have jointly developed a paddy husk combustor-cum-heat exchanger for the purpose, at the instance of the Food Corporation of India (FCI) and the Union Ministry of Food and Agriculture. The first plant installed at FCI's rice mill at Durgapur has successfully completed its trial runs recently and has been handed over to the FCI for regular operations. The plant has the capacity of drying about 1.2 tonnes of parboiled paddy by burning approximately 100 kg of husk per hour.

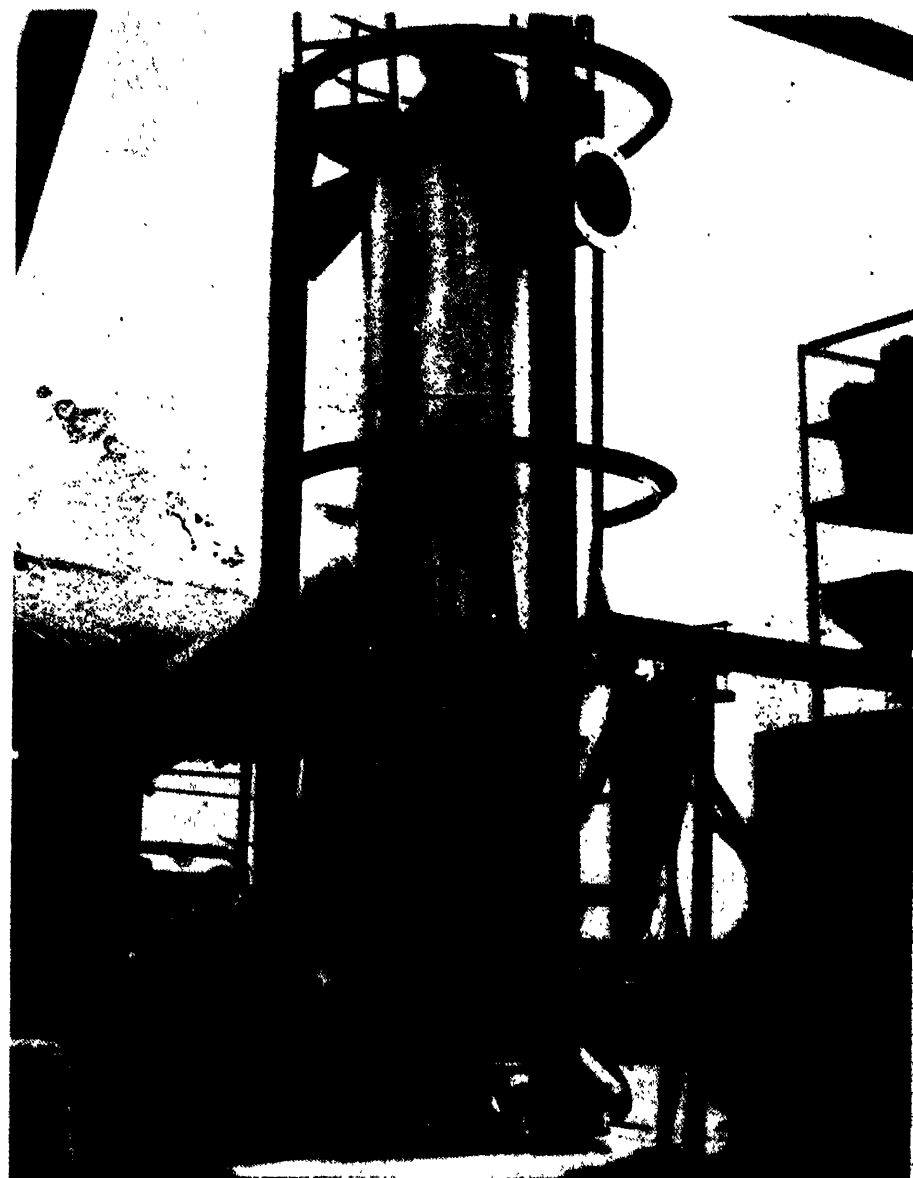
Most of the modern rice mills in the country presently dry parboiled paddy in furnace oil based units. While such drying is costly, increasing scarcity of petroleum fuel, which is also imported, adds to their problems. Besides bringing the waste husk into use eventually reducing drying cost, the development of the plant will also help conservation of foreign exchange to a considerable extent.

FCI alone has 22 mills with parboiling facility, each of which is

required to dry 60-80 tonnes of parboiled paddy per day with an average consumption of about 30 litres of furnace oil for drying one tonne of parboiled paddy. The annual requirement of furnace oil at the attainable capacity of 18,000 tonnes per annum for these 22 units works out to about 12,000 kilo litres valued at about Rs. 1.85 crores. Use of paddy husk combustor-cum-heat exchanger will result in a saving of very substantial amount of foreign exchange.

The installation consists of a vertical cylindrical combustor with a heat exchanger mounted over it. Husk is fed by screw conveyor and injected into the combustor with the help of conveying air from a blower and a distributor. Husk is burnt in suspension with primary air from a second blower, which is passed through a hollow main shaft and a stirrer casting at the bottom of the combustor. This is rotated very slowly, and

*(Continued on page 131)*



**Paddy husk combustor**



**ALL IN THE HEAD** by David Cohen, *Kestrel Books* (published by *Penguin Books Ltd.*, Harmondsworth, Middlesex, England) (Indian Agents : *Penguin Overseas Ltd.*, 706-Eros Apt., 56-Nehru Place, New Delhi-110024), 1979, Pp. 124, £ 3.25 net.

**M**OST of us—particularly artists and people in love—have aesthetic appreciation of the body's outward form. Few of us take the time to understand its inner structures and functions which are far more complex than any computer or mechanical invention, yet simple and economical in principle. When, if ever, man will understand the *why* of his existence is something else. And whether he will ever understand the relationship between the most complex parts of his physical equipment, the *brain* and the imponderable and immeasurable thought processes associated with it, is another moot question.

Most of us in good health take the senses for granted and for us tasting, hearing, smelling and seeing seem to be so natural that we do not bother to think about them at all. The communications network (brain plus the nervous system) controls our every thought, our every motion, every step we take, every impression we get, even at foetus stage.

The human body is, among other things, a highly tuned instrument for the perception of the external world. Vivid reports pour into man's brain through his eyes, ears, skin, nose and mouth, describing in detail

the variety of things on earth. Just as it is impossible to conceive of the human head without eyes and ears, so it is impossible to conceive of a meaningful life that does not partake of the world through the senses.

Experiences undergone by men in solitary confinement show that a human being deprived of contact with the external world cannot stand the effect; it is disturbing, then terrifying—and at last the prisoner hallucinates the world he needs.

In fact, the author of the present book stresses the importance of the most incredibly complicated processes, viz., senses of vision, smell, taste, hearing and touch.

In the introduction the author writes what the book is about, i.e., the working of the brain, the way that we can see, hear, feel, talk, touch and behave. He asks us to picture the brain as a huge board of flashing lights, on which each cell is represented by a light. Every cell has either to be ON—firing and active—or OFF—inactive. He also points out here that he has tried to show how curious, complicated, interesting and at times simply *odd* is the way we and our senses are organised.

Chapter I discusses the sense of vision, including the anatomy of the eye and the way we learn to see. Chapter II deals with smell and taste, Chapter III concerns communication which also includes the origin of language. The Fourth chapter lucidly explains what are sounds and the processes of hearing. In the Fifth and last chapter the author describes the way we react—the way we look at things or the way we feel—love, happiness, surprise, anger, fear, suffering, disgust, contempt, etc.

The book under review is mainly meant for non-specialists and also for school children. Written in simple language, each chapter is illustrated with interesting diagrams. There are also a few cartoons. The step-by-step exposition of the subject matter is praiseworthy.

The author has described many experiments carried out on the senses. He also suggests some that we might do ourselves. The results of these experiments are amazing and they convince one of the extraordinary powers of one's head and its contents. However, if the view of Margaret Liley (*The Secret World of The Unborn, Reader's Digest*, November 1965)—that the unborn's eyes open and shut about the eighth month and are able to distinguish between light and shadow and that the womb is a noisy place and even the outside noises come through to the baby quite clearly apart from mother's heart beat and rumbling of intestines—is accepted, it goes against David Cohen's opinion (p. 89) : "In the chapter on vision, I pointed out that we are not born seeing. We have to learn to see. You might expect, therefore, the baby to be born a little deaf, too. Cooped up in the womb, what could it have heard?"

The book is very interesting but the price is somewhat on the high side.

C. LALITHA

**PROGRESS IN POLYMER SCIENCE, VOLUME V** by A.D. Jenkins (Ed.), *Pergamon Press*, Headington Hill Hall, Oxford OX3 0BW, England, Pp. 237, \$ 37.50

**T**HIS journal aims to bridge the knowledge gap between the original literature and the working knowledge of the individual scientist in the field of polymers. Research in the various branches of polymer science is expanding very rapidly. At present, several thousand original papers and numerous patents are published annually in this field by the workers of several countries. And the advent of multidisciplinary journals have made the situation more complicated for the individual scientist to locate the literature of his interest.

Under these circumstances, the effort of this journal to keep abreast the scientists in their specialized fields is quite appreciable.

The volume under review is the fifth issue of the journal. It consists of three articles. Gas chromatographic measurement of polymer structure and interactions is its first topic. Usually gas chromatography has been extensively used for separation and estimation of organic materials. Recently, it has been used as a tool to get information regarding the structure and thermodynamic parameters of polymers. These potentialities have been discussed in the review. The review includes the method to estimate the glass transition temperature and degree of crystallinity of high molecular weight polymers from the gas chromatography. Besides these major applications, several other types of applications have also been discussed. The review contains 173 references and covers literature upto 1976.

Photochemical probes in polymers is the subject of the second article. Studies on photoimaging systems and polymer photodegradation are well-known in the recent past. These works mainly deal with practical aspects such as photography, lithography, etc. But, only recently, efforts are made to understand the details of the light polymer interactions on a microscopic level. The review describes such efforts and the main conclusion thus obtained. Investigations of the effects of microenvironmental polarity on the kinetic behaviour of photoisomerization process have been included with few examples. The role of impurities in polymers on luminescence is also described. The phenomenon of energy migration along a polymer chain has been well documented for a number of polymer systems. The review covers literature upto 1975 and has 108 references.

Polymer-supported catalyst is the theme of the last article. The use of both soluble and

insoluble catalysts in chemical reactions is almost as old as chemistry itself. Acid catalyst is a typical example of homogeneous catalysis which has been known and applied for a long time. On the other hand, the hydrogenation of unsaturated compounds by metals such as platinum, palladium or nickel, a representative example of heterogeneous catalysis, goes back to the early nineteenthies. The major disadvantage of homogeneous catalysts is the need to separate the reaction products and to recover the catalyst, which is often somewhat more expensive than a 'classical' heterogeneous catalyst. Then appeared the idea that the advantages might be retained and disadvantages overcome, if the homogeneous catalysts were either deposited onto a solid support or, better, chemically bound to it. So was born the 'supported homogeneous catalysis'.

The review is mainly divided into two sections. The first section gives the details of methods used to anchor known homogeneous catalysts upon a polymer. It also describes briefly the applications of bounded catalysts. The next section contains the kinetic aspects of supported catalysts and a comparison with homogeneous catalysis in order to shed some light on the influence of the presence of 'a support' on the catalytic phenomena. Lastly, the technological aspects of the polymer supported catalysis is briefly given. There are several tables at the end of the text which facilitate in locating the work on any particularly support-polymer or on any functional group. The review covers 364 references and literature published upto 1978.

This volume provides three interesting review articles for those actively engaged in research and for those interested in the technological aspects of polymers. This issue as well as other issues of this journal will be a valuable source of information to all polymer scientists.

ALOK R. RAY

**CHEMISTRY OBJECTIVE TESTS** edited by N. S. Gnanapragasam, *Sultan Chand & Sons.*, 23, Daryaganj, New Delhi-110002, Pp. 332, Rs. 12.50.

**U**NDERSTANDING of chemistry and other sciences requires much more than mere memorization and cataloguing of factual data. A student should be able to develop dexterity in solving problems and the ability to grasp the concepts. This book will be of help to students in learning the principles of chemistry as well as solving new problems.

With the introduction of 10+2 pattern of education and the reforms introduced in the examination system, the conventional essay type questions are being replaced by objective type questions at the school, college and university levels. The marking of objective type questions is quick, reliable and reproducible. Moreover, a large portion of the syllabus can be covered.

The book under review contains more than 2,300 objective type questions in chemistry from general, inorganic, organic and physical chemistry of the B.Sc. level. On the face of it, this multiple choice pattern of objective questions is simple and easy for the candidate. But, it requires the full understanding of the subject to find the only correct answer in the three to five seemingly correct answers.

It would have been better for the students had the author revised the text and removed certain factual mistakes which have crept in the final print. There are printing errors which could have been removed at the time of proof reading.

On the whole, the book may be useful for those preparing for competitive examinations and also for those who want to test their knowledge of chemistry.

SUBHASH C. HARI

## BOOK REVIEWS

**MOMENTUM TRANSFER OPERATIONS** by Santosh K. Gupta, *Tata McGraw-Hill Publishing Company Limited.*, 12/4, Asaf Ali Road, New Delhi-110002, 1979, Pp. 336, Rs. 36.00

ANY chemical plant is visualised as a sequence of particular unit operations. Knowledge of unit operations simplifies the study of large and complex chemical industries. Unit operations involve only physical changes, in particular, the transfer of momentum, heat and mass. An understanding of transport phenomenon is a pre-requisite for understanding of topics covered in unit operations. The book under review is entirely devoted to unit operations which involve the transfer of momentum, and fills the gap that exists in this subject.

An introduction to the elements of unit operations, property estimation and accuracy analysis is given in the first two sections. The inter-relationships between process design, equipment design and unit operations are functionally discussed.

Principles of fluid mechanics with special reference to flow through pipeline systems and fluid flow and pressure measuring devices are briefly described in sections three and four. Details of structure and operating characteristics of some common pumps and compression equipment such as positive displacement pumps, centrifugal pumps, blowers and compressors are dealt with in section five. In addition to design formulae, the scope and limitations of each type of pump and compressor as well as their selection factors are presented. The same pattern of presentation is followed throughout the text.

Vacuum production devices such as oil sealed rotary vacuum pumps, roots pumps, diffusion pumps, steam jet ejectors and equipment used for mixing and agitation operations are detailed in sections six and seven. The principles governing the flow of solid-fluid and comminution (size reduction of solids) systems are discussed in sections eight and nine. Some of the common crushing and grinding equipment such as jaw crushers, gyratory crushers, roll crushers, pan mills,

disc crushers, ring roll and ring ball mills, hammer mills, tumbling mills and fluid energy mills are described briefly. Selection chart for size reduction equipment on the basis of hardness and fineness of material is also presented. The next two sections are devoted to the study of separation devices working on the principles of gravity and centrifugal forces. In the last three sections, topics such as flow of fluids through packed beds, fluid-solid conveying systems and filtration devices are briefly but functionally explained.

The book is useful for students of chemical engineering and those practicing engineers engaged in plant and equipment design. Both S.I. and British units are concurrently used throughout the book. For every type of equipment, the design equations are derived from first principles. These are adequately supplemented with design drawings, characteristics curves and selection factors. Reference literature cited at the end of each section is an added asset.

V. GOVINDARAJULU

## Books received

1. **INTRODUCTORY CHEMISTRY** by M. Katyal, Oxford University Press, New Delhi, Pp. 288, Rs 10.50.

2. **CHROMATOGRAPHY OF PETROLEUM AND PETRO-**

**CHEMICALS** Ed. by Sukumar Maiti, *Symposium Director, Materials Science Centre, Indian Institute of Technology, Kharagpur*, Pp. 374 + Index.

3. **DIAGNOSTIC TESTING IN**

**ADVANCED CHEMISTRY** by A. Brookes and W.A.H. Scott, Hodder and stoughton, Mill Road, Dunton Green, Seven Oaks, Kent TN 13 2YD (U.K.), Pp. 177, Test Vol. £ 1.85; Complete Vol. £ 3.25.

## MEDICAL NOTES (Continued from page 125)

munization is the basic and practical tool to control the disease. The primary course of active immunization in combination with immunization against poliomyelitis, tetanus and pertussis (whooping cough) is ad-

ministered within the first year of life, preferably at about the third month. This is followed by one stimulating dose administered two years later and another at the time the child

goes to school.

PRADIP CHAKRAVARTI  
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Dayanand Med. College & Hospital  
Ludhiana-141001*

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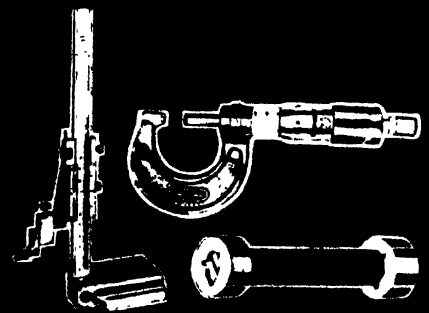
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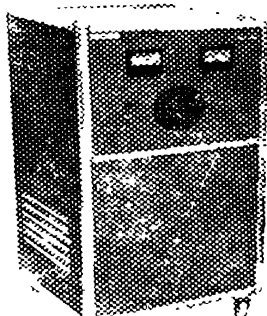
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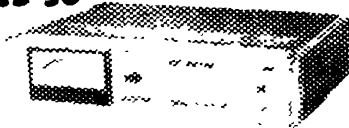
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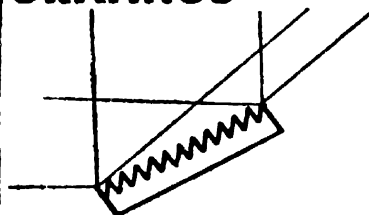
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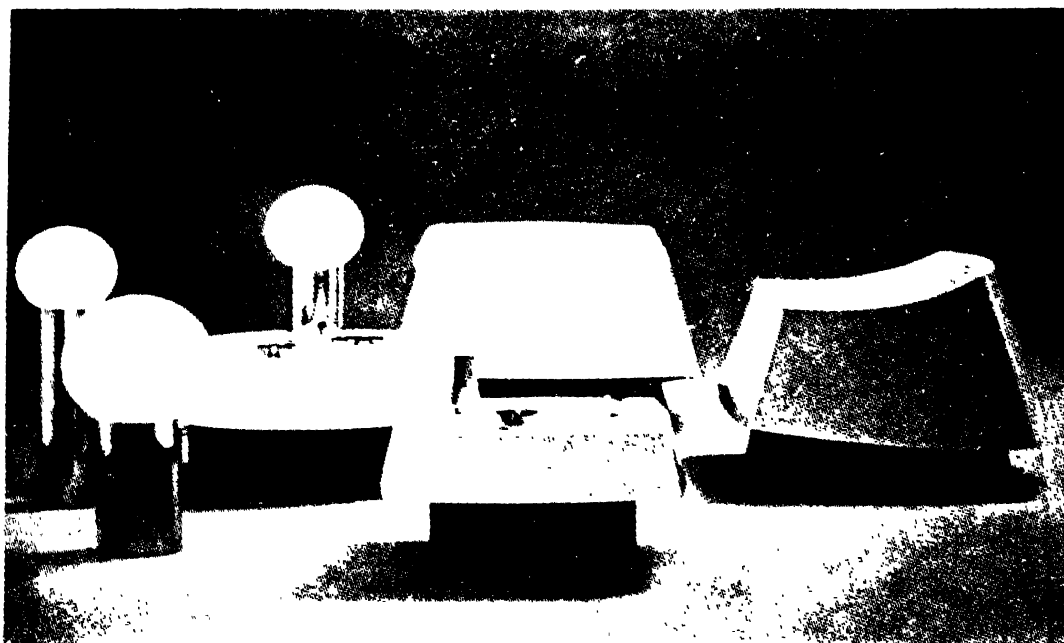
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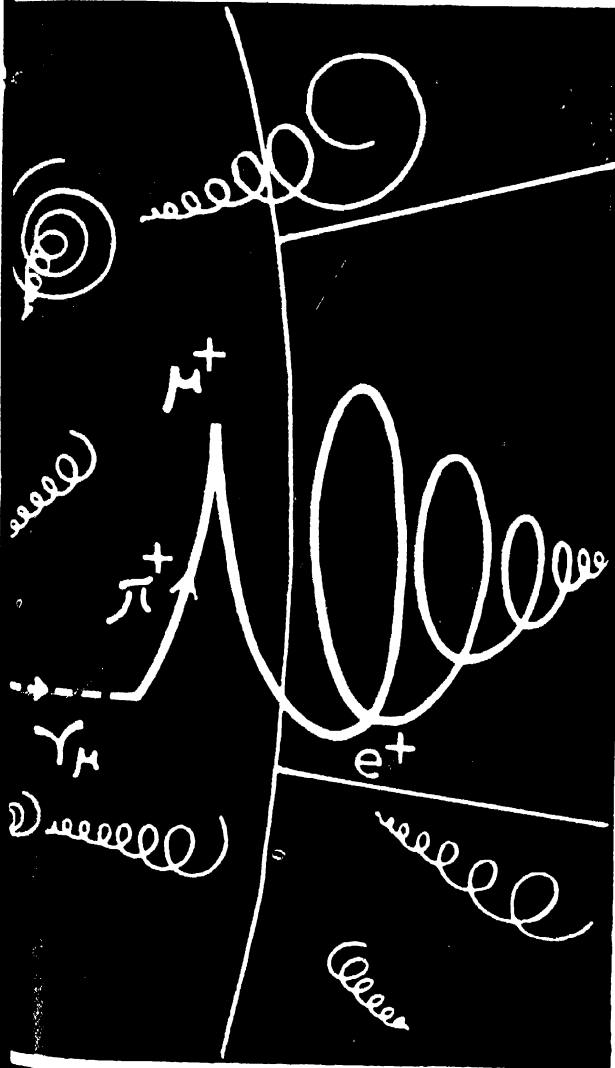


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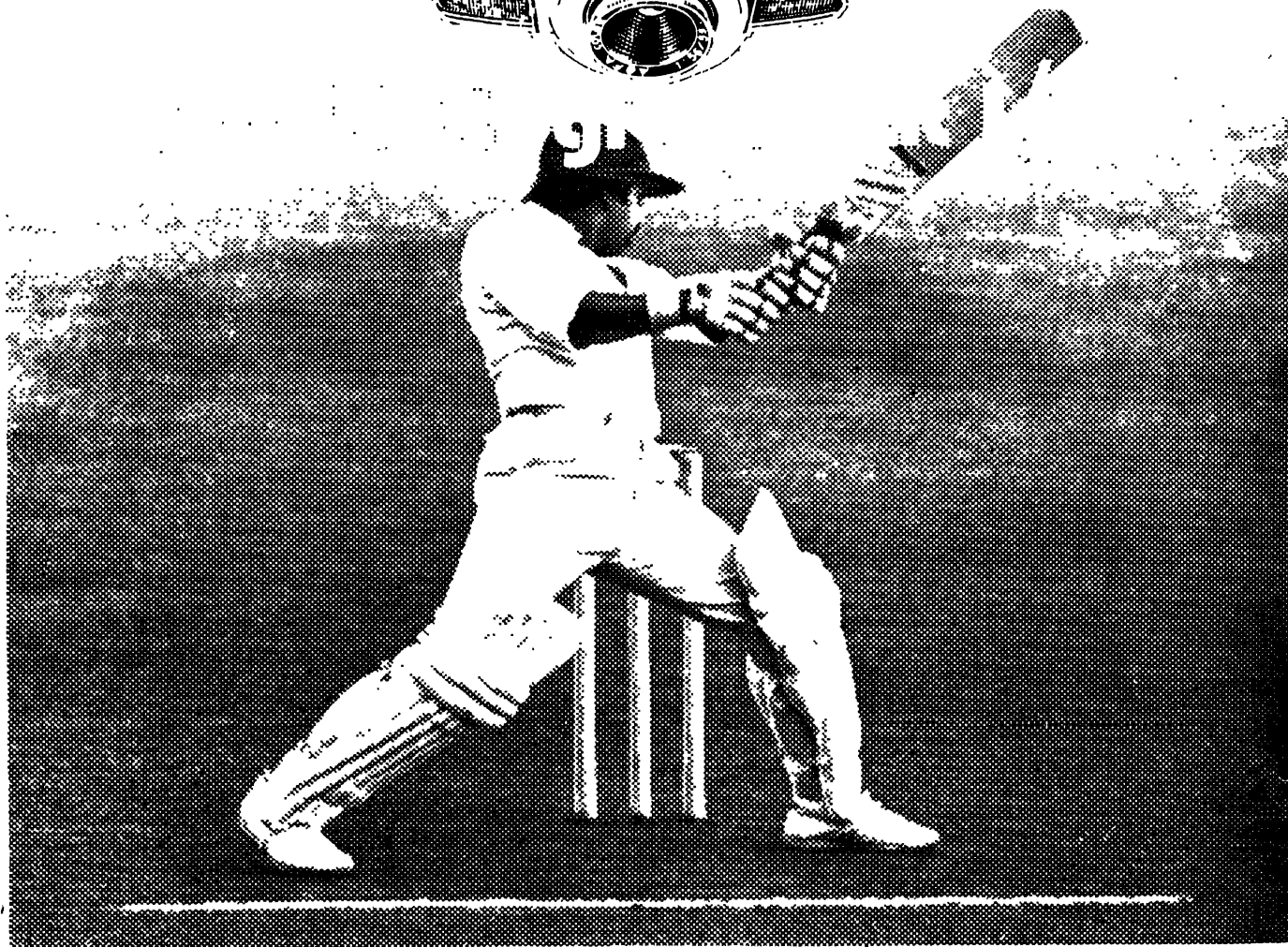
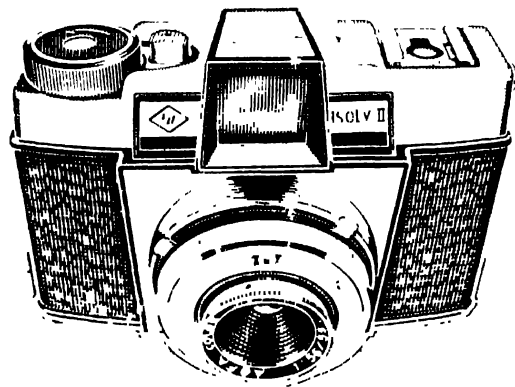
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VOL. 17

MARCH 1980

NO. 3

Cover: Dr. Abdus Salam. The accompanying illustration is the tell-tale track (thick line) of a particle in a bubble chamber which proved the existence of neutral currents as predicted by Salam and Weinberg (From: a photograph taken at Argonne National Laboratory, U.S.A.)

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### Regressive scientific research

Sir, The article **Regressive scientific research** by Jagjit Singh (*S.R.*, October 1979) was highly impressive and to the point with reference to the present status of researches as a whole. No doubt, the researches all over the world could be grouped into two types — the basic and the applied ones. The aim of basic research in any scientific field is to resolve the hidden mysteries in either living or non-living components of nature. Its importance, hence, cannot be ignored. It gives rise to the birth of the applied aspect. Both types are, therefore, interrelated. The direction of the applications of basic research depends upon the mental make up and approach of a researcher engaged in a particular problem, intensity of the problem in an area concerned, etc.

However, what we call regressive type of research can be certainly reduced. If we wish to see that our researches do not go waste in future, we would have to think of them seriously in terms of their role in national development. The major problems which have direct bearings upon public welfare need to be pooled and highlighted from time to time. Research projects related to them could be financed accordingly by various financial agencies. What we lack are not the talented researchers and research facilities, but proper research programmes. Aquatic weeds in various water bodies like ponds,

lakes, canals, etc. is one of the most serious problems in many parts of India. There is urgent need to find ways to control them. Such type of approach could possibly be one of the answers to control the increasing amount of regressive type of research.

R. K. RAGHUVANSHI  
*Lecturer, Botany Deptt.*  
*University of Rajasthan*  
*Jaipur*

### King's dilemma

In the article **Exponential variation with time—a natural law of change** (*S.R.*, January 1979), H.S. Ray has narrated the story how a clever person brought ruin to a king who thoughtlessly acceded to give to him one grain of rice one day, two grains for the second day, four grains for the third day and so on for a month or two.

Prof. G. Gamow has given a slightly different and interesting version. According to him, an Indian king wanted to reward his minister for inventing the absorbing and thrilling game of chess. The crafty minister made the innocuous demand of grains of wheat in the above manner for all the 64 squares of the chess board. The king was delighted at such a simple request but belatedly realized that the entire world's wheat production for the period of several centuries would not suffice to satisfy the demand of his minister. The number of grains asked for by the minister may be represented as follows :

$1 + 2 + 2^2 + 2^3 + 2^4 + \dots + 2^{63} = 2^{64} - 1$ , which comes to an astounding 18, 446, 744, 073, 709, 551, 615.

S. K. GURTU  
*Defence Science Laboratory*  
*Metcalfe House*  
*Delhi 110054*

### Starwatching

Sir, Kudos to the series **A Guide to Starwatching** through which *S.R.* has kindled the interest of the readers in the night sky. *S.R.* can further encourage amateur astronomy by expanding the scope of the monthly feature **Planets and their positions** to cover more details, like the observational information on Uranus, Neptune, favourable minor planets, meteor showers, etc. All these celestial phenomena are within the reach of the amateur's optical aids (binoculars and small telescopes) but are not observed for want of information.

K. RAJAGOPLAN  
*Central Ground Water Board*  
*Bangalore 560 041*

### II

Sir, This is to thank you for your **Guide to starwatching** serialised over the 12 months in 1979.

I still remember the thrill I received when, after locating the "V" of the Taurus, I spotted twelve constellations one after the other, using your illustrations as a guide. The beauty of the Pleiades cluster, as seen through binoculars, is better seen than described.

I would recommend to all my friends who have not yet made an acquaintance with the stars to do so. The pleasures of starwatching are too many to be missed.

SANJEEV SABHLOK  
*1/2, Ulsoor Road*  
*Bangalore-560042*

### Hypercholesterolemia

Sir, **Cholesterol—a cause for concern** (*S.R.*, November 1979) gives us an opportunity to focus our attention on the prevention and treatment of hypercholesterolemia.

We now have the knowledge to prevent and symptomatically treat hypercholesterolemia. It is wiser to prevent the condition in the first instance. The following measures can help :

1. Take less than 30% of your total calories in the form of fat. Atherosclerosis is more common when fats constitute more than 40% of the calories.

2. Restrict your consumption of animal fats. They have large amounts of saturated fats. They are harmful. Instead of animal fats, take vegetable oils like groundnut oil, sunflower oil, safflower oil, cottonseed oil or gingelly oil. These vegetable oils have larger quantities of polyunsaturated fats which prevent hypercholesterolemia and its complications.

3. Regular exercise is invaluable in burning out excess fats from the body.

Drugs can be tried in hypercholesterolemia if it cannot be controlled by diet and exercise. Cholestyramine, thyroxine and estrogens are specifically used in its management. Cholestyramine binds to bile salts in the intestine and prevents their absorption; thus bile salts are excreted in the faeces. Also, production of bile salts increases to replenish the loss. Since the latter are derived from cholesterol, larger amounts of it are utilized. Consequently, the concentration of cholesterol in blood decreases.

Thyroxine, the hormone of the thyroid gland, acts through a different mechanism. It both increases production and excretion of cholesterol. Obviously, to lower the blood cholesterol, excretion must be higher than production.

G. R. SRIDHAR  
D-20, Medical Officers' Quarters  
Visakhapatnam 530002

## Balanites

Sir, I was surprised to read the article *Balanites*—a contraceptive plant of the Indian desert in Dec. 1979 issue of your journal. Much of the information given in the article has already been published in May 1976 issue of *Science Reporter* under the heading *Balanites roxburghii* as a source of diosgenin.

In the present article, the distribution of plant has been given as wild all over the Thar desert and also Panjab and Sikkim. From this statement it appears that Thar desert is having a lavish vegetation. If it is the case, then why it is a desert? Similarly, I fail to understand where the plant grows in Panjab and Sikkim.

The information provided in the article is based on old floras, the present position is quite different. During a special survey of Indian deserts in 1978, I could find the plant only at a few isolated protected places. In the semi-arid areas of Sagar Division in M.P. also the plant could be seen at a few places. During the field studies I have found that the majority of the plants have been burnt as fuel wood and position of *Balanites roxburghii* now is not better than *Dioscorea deltoidea*.

If the plant is to be economically exploited it will have to be cultivated, but the return may not be much. As the position exists today instead of diosgenin shortage there is a diosgenin glut. Recovery of protein and fat is also doubtful from it, because much of the seed kernels are eaten by the insects by the time the fruit matures.

The information regarding *Dioscorea* spp. is not up to the mark, it refers to *Dioscorea deltoidea* only. *D. floribunda* and *D. composita* have

been cultivated in some places in India and these plants are providing raw material to the industry.

Lastly, the title of the article is misleading. *Balanites* as such is not used as a contraceptive, but the extract of it has to undergo many physicochemical changes before it is incorporated into a pill.

H. S. PURI

Research Officer, Botany Deptt.  
Panjab Univ., Chandigarh

## Tunnel makers

Sir, *Tunnel makers* (S.R., Nov. 1979) by S.K. Beri has been limited to a few examples of tunnel-making insects. Besides the *Agromyzidae* family of the order Diptera, there are other insect pests like citrus leaf-miner (*Phyllocnistis citrella*), a notorious pest of citrus in India; *P. toparch* on grapevine and *P. chrysophthalma* on cinnamon. All these species belong to the order Lepidoptera and the family *Phyllocnistidae*. The order Hymenoptera (family *Tenthredinidae*), also have some leaf-miners. Out of these, *Fenus pusilla* birch leaf-miner is an important pest in the U.S.A.

These leaf-miners can easily be controlled by the application of systemic insecticides like phosphamidon, methyldemeton, dimethoate, disulfoton, phorate, etc., which are translocated in the systems of plants after their application.

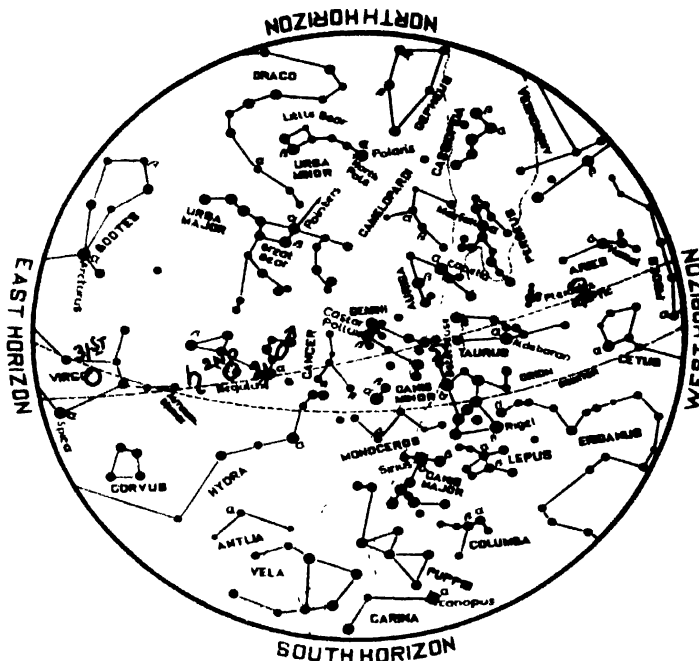
JITENDRA KUMAR

B. S. BHARDWAJ

Divn. of Entomology  
I.A.R.I., New Delhi 110012

# Planets and their positions

April 1980



PLANETS		MAGNITUDES							MOON	
		-1	0	1	2	3	4	5		
♀	VENUS	◆	●	●	●	●	●	●	○	FULL MOON 2 <sup>ND</sup> , 31 <sup>ST</sup>
♂	MARS								◐	FIRST QUARTER 23 <sup>RD</sup>
♃	JUPITER									
♄	SATURN									

## The moon

**N**EW moon occurs on 15th at 9.16 a.m. and full moon on 30th at 1.05 p.m. I.S.T. The moon passes very close to Mercury on 13th, nine degrees south of Venus on 18th, about two and a half degrees south of Mars and about a degree south of Jupiter on 24th and half a degree south of Saturn

on 26th. The lunar crescent becomes first visible after the new moon day in the evening of 16th.

The moon is at perigee or nearest to the earth on 14th and at apogee or farthest from it on 27th.

## The planets

**Mercury (Budha)**, a morning star, rises about an hour before

sunrise during the month. Towards the end of the month, it is too near the sun to be visible. It is at the greatest western elongation of about 28° from the sun on 2nd. It moves from Aquarius (*Kumbha*) to Aries (*Mesha*) through Pisces (*Mina*). Its visual magnitude varies from + 0.6 to - 0.5.

**Venus (Sukra)** an evening star, visible on the western horizon sets about two and a half hours before local midnight during the month. It is at the greatest eastern elongation of about 46° from the sun on 5th. It passes about 9° north of the star Aldebaran (*Rohini*) on 15th. It is in Taurus (*Vrisha*). Its visual magnitude is about - 4.0.

**Mars (Mangala)**, visible in the evening sky, sets about three hours after local midnight during the first half of the month and about two hours after it during the second half. It becomes direct on 6th. It passes about 2° north of the star Regulus (*Magha*) on 30th. It is in Leo (*Simha*). Its visual magnitude varies from - 0.3 to + 0.4.

**Jupiter (Brihaspati)**, visible in the evening sky, sets about three hours after local midnight during the first half of the month and about two hours after it during the second half. It becomes direct on 26th. It is in Leo (*Simha*). Its visual magnitude is about - 1.9.

**Saturn (Sani)**, visible in the evening sky, sets about an hour before sun rise during the first half of the month and about two hours before it during the second half. It is in Leo (*Simha*). Its visual magnitude is about +0.9.

(Source : Positional Astronomy Centre, India Meteorological Department, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700 053.)

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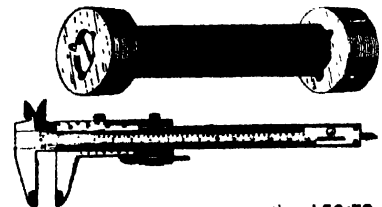
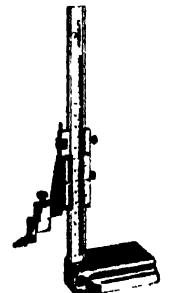
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JAGJIT SINGH

**By resorting to gauge fields, Salam has unified the two, weak and electromagnetic, forces out of the four in nature, into one called 'electro-weak'**

**A**BDUS Salam's Nobel Prize winning new theory unifying two of the four fundamental forces of nature is an old dream that seeks to unify the immense diversity of things in our universe. Xenophane's "All is one", Aristotle's all-pervasive substance, Cartesian plenum, 19th century ether, Maxwellian electrody-

Herman Weyl are all attempts with varying mixtures of physics and metaphysics to realize that ancient goal. Salam-Weinberg theory of what Salam calls "electro-weak" interaction is yet another endeavour to unify the apparent diversity of things. It is as great an advance in physics today as was the Faraday-Maxwell unifica-

and forces a simpler underlying order. If the four forces, for example, could be shown to have a common origin and thus viewed as different manifestations of a single more fundamental entity, a more satisfying understanding of nature would ensue. It could perhaps throw new light on many unsolved problems of modern phy-

# Abdus Salam : TOWARDS A UNIFIED FIELD THEORY

namics, Mendeleev's classification of elements in the Periodic Table, Ostwald's energetics, Einstein's relativity, unifying theories like that of

tion of electricity and magnetism a century ago. In order to comprehend it a short digression on the current status of unification mechanisms in modern physics is necessary.

All matter in the universe is now believed to consist of a few scores or more of elementary particles, and all phenomena the outcome of their interaction through the agency of four kinds of forces. They are called strong, electromagnetic, weak and gravitational forces. For the past few decades the feeling has persisted that nature need not be so complicated and that it should be possible to discover in the diversity of particles

sics and cosmology like the origin of the universe, the vexing question of black holes and Schwarzschild singularity. Who knows? But the task of unifying them all still bristles with great difficulties. For the four fundamental forces of nature seem at present as unlike as chalk and cheese. Thus gravity keeps the planets coursing in their orbits around the sun, electromagnetism sustains all chemical reactions like combustion and respiration, strong interaction between nuclear particles like protons and neutrons makes the sun and stars shine, and weak interaction governs more weird processes like  $\beta$ -decay of radioactive elements. Further, while the former two are long range ex-

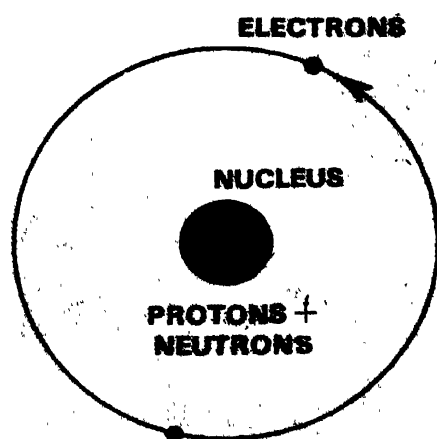


Fig. 1. Model of an atom

Dr. Jagjit Singh, the internationally known science writer, is the winner of Kalinga Prize for science popularization.

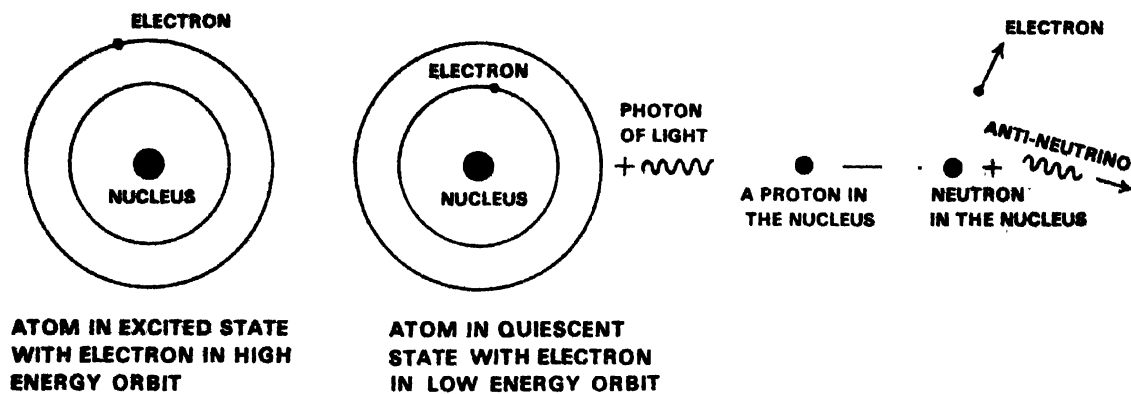


Fig. 2. Parallel between emission of photon and beta particle. Emission of photon (Left); emission of beta particle (Right)

tending up to and beyond the remotest stars and galaxies, the latter are short range effective only within subatomic distances. They are equally disparate as regards their effective strength. Thus if we were to denote the strength of the most powerful of these four forces—strong interaction between two particles—by 1, then the electromagnetic force between the same particles has a strength of about  $10^{-2}$  and the weak force of  $10^{-5}$ . The gravitational force is the weakest. It is only  $10^{-39}$ .

The widely disparate properties of the four forces has not deterred theorists from seeking a common basis for them all. Einstein, for example, devoted much of the last part of his life to the search for a unified field theory of gravitation and electromagnetism. Other physicists followed him, but the results of their work were never convincing. During the past few decades greater understanding of weak interaction has opened up other choices not available to earlier physicists. One could not even begin to unify electromagnetic and weak interaction unless one understood the latter at least as well as the former. This fuller understanding of the weak interaction was slow coming. Ever since its discovery around the turn of the century, its history is a series of mystery stories. In each story a mystery appears at first only in a vague form only to deepen in the next. Clues to the solu-

tion are present but are overlooked or discarded usually for the wrong reason! Finally, the hero comes up with the right explanation until the next corpse is unearthed. It is therefore no wonder that during the past eighty years since the discovery of the first "corpse", several Sherlock Holmes have appeared. Salam is the last of the half-dozen in this illustrious line.

The saga of weak interaction began with the discovery of the first whodunit in 1896 by the French physicist, A. H. Becquerel, when he found that unopened boxes of photographic plates kept in his drawer were getting badly fogged as if exposed to light. He investigated the situation and was able to trace the culprit. It was the radioactive emanation from a piece of uranium mineral that he had kept in the same drawer. The radiative emission from the mineral had penetrated, very much as X-rays do, the thick black covering in which the plates were wrapped and thus obscured them. But the origin of the offending radiation, and, indeed the whole phenomenon of radioactivity itself, on which Becquerel had accidentally stumbled, remained a great puzzle for a long time. The mystery basically was the casualty of a sacred tenet of modern physics. For, oddly enough, natural radioactivity seemed to violate the well-known law of conservation of energy.

The puzzle was not resolved till 1930 when Wolfgang Pauli suggested that radioactive elements like radium and thorium decay not only by emitting electrons or beta particles that are easily observed but also a new kind of elementary particle now called antineutrino that eluded observation. It was invoked to save the law of energy conservation. For, as will be seen more clearly in the sequel, in a typical radioactive process, a neutron in the atomic nucleus spontaneously breaks down into a proton and an electron. Since the sum of the kinetic energies carried off by the splinter electron that flies off and the proton that stays put in the daughter nucleus is always less—never more—than that of the parental neutron before its decay, both the alternatives physicists faced seemed at first sight to be grim. They had either to accept the breakdown of the sacrosanct law of energy conservation or they had to postulate the existence of a new particle that somehow always escaped observation for reasons which were not understood till two decades later. Such a particle emitted along with the proton and the electron in the disintegration of the neutron could save the conservation law of physics by carrying off the missing energy. Pauli ventured to adopt the second alternative even though the introduction of a new elementary particle was not the casual affair it has since been found to be.

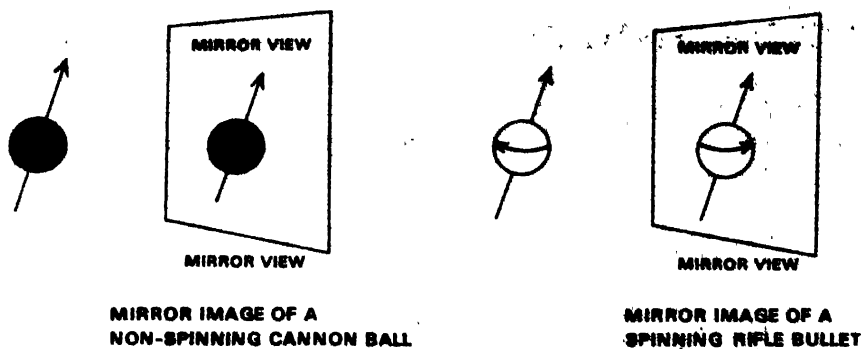


Fig. 3

many elementary particles in the "nuclear zoo", proposing a new particle scarcely raises eyebrows. But, in 1930, it was a very daring step indeed. Only two particles were then known—the electron and the proton. Destroying the simplicity of the subatomic world by adding a third was considered to be sheer heresy. No wonder very few physicists took the idea seriously. Some eminent physicists like Bohr were even prepared to accept the breakdown of the law of conservation in radioactive decay rather than admit the existence of a new unobservable particle. Only the celebrated Enrico Fermi, the architect of the atomic bomb, took up Pauli's suggestion and managed to resolve the puzzles bedeviling radioactivity at one blow.

Fermi began with the well-known fact that atoms consist of nuclei surrounded by electrons and nuclei consist of proton and neutrons (Fig. 1). When the number of neutrons in the atomic nucleus happens to be one too many for its stability the excess neutron turns spontaneously into a proton with the emission of a beta particle or electron as well as Pauli's hypothetical particle, antineutrino, as shown in Fig. 2(b). This transition of the nuclear neutron into proton in the nucleus of a radioactive atom with the emission of an electron necessarily involves the creation of an electron because there are no electrons in the nucleus. The process is analogous to the radiation

of light when excited atoms make quantum jumps to states of lower energy. The emitted photons of light are created during the radiative transitions simply because there are no pre-formed photons in the atom waiting to be emitted any more than there are electrons in the atomic nucleus. Since the quantum theory of radiative emission, or, electromagnetism, was well understood in 1933, Fermi patterned his theory of beta decay on this model (Fig. 2). His theory was incredibly successful in explaining almost all observed aspects of beta decay for nearly twentyfive years when it was badly shaken by the so-called parity crisis in 1956.

In the parity crisis some of the symmetries of space and time hitherto assumed to underlie the fundamental laws of nature did not seem to hold perfectly on the subatomic scale. The first to breakdown was what may be called space symmetry (P), the symmetry involved in the law of conservation of 'parity'. This is merely to say that if a physical process occurs, its 'image' in a mirror is also a *possible* analogue. This may seem odd as the mirror "image" is only an optical illusion of the real. But the point is not that the image is real or virtual, but that the image can in principle be made real. Consequently the parity principle is only an embodiment of the reflection symmetry of nature. It merely asserts that the world of the looking-glass is a possible world even though like the left-hander it may look odd. Thus a looking-glass book may seem written in an odd kind of language; but it is a possible language that could be read. It is the same for all artifacts like clocks and gloves. There can be no real bar to the existence of mirror images of objects so that if a left-handed glove exists so can its mirror image, the right-handed one.

## MIRROR

ABCDEHI      IHEDCBA  
 FGJLNPQ      QJNLGP

Fig. 4

However, the breakdown of parity that occurred in 1956 showed that there are certain rare processes whose mirror images are not realisable in our world. A case in point is beta decay of radioactive atoms we have been considering. There is observed an asymmetry in the electrons emitted in radioactive decays. It arises from the fact that in such decays the emerging electrons behave (speaking analogously) like spinning bullets shot out of a rifle rather than cannon balls fired without spin from a cannon. A non-spinning cannon ball shot out of a cannon looks essentially the same in a reflected system. But a rifle bullet, spinning in a definite sense, say, right-handed about its line of flight, will appear left-handed in a mirror—an essentially distinguishable situation (Fig. 3). In a precisely analogous fashion in certain radioactive processes the neutron whose decay results in the emission of an electron behaves like a rifle, not a cannon.

It happens that whenever a beta particle that has spin gets sent out as a result of such radioactive decay, it tends to spin in a left-handed way about its direction of flight. It is this spin that causes the asymmetry referred to above.

One consequence of the failure of parity in beta decay was the proliferation of the possible number of beta decay interactions because they could now be not only parity-conserving but also parity-violating. It was at this stage that the problem of beta decay was taken up by E.C.G. Sudarshan in the summer of 1956 at the instance of his mentor, Professor R. E. Marshak.

Sudarshan had to decide the basic mathematical form for the description of beta decay interaction. Here he faced a virtual *embarras de choix*. For there are many mathematical forms devised by mathematicians to specify precisely the physical entities we encounter in mapping the universe around us. The commonest is



Fig. 5. Particle exchange can lead to attractive and repulsive forces

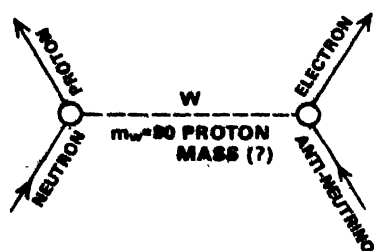
the real number system we all use to measure physical quantities like mass, time, length, volume, density, energy. Such a quantity which is fully described by a single real number is called scalar because the number in question can be represented by a point on a scale.

But there are other more complex physical entities which cannot be specified by a single number or a point on a scale. Velocity, for example, requires for its complete specification not only a magnitude but also a direction that is commonly represented by an arrowed line segment. Such an entity is called a vector. There are yet others which like the spin of a rotating top require for their specification, in addition to the magnitude of spin and direction of the spin axis, the mode of their spin.

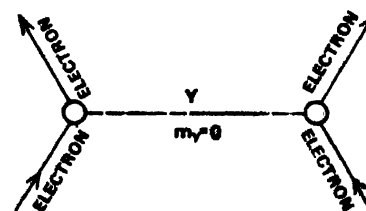
Spin therefore belongs to another category of vector known as axial vector. Next in complexity is an entity like stress or strain in a supporting beam or column. Its full specification requires a generalisation called tensor. Tensors are like vectors in that they are geometrical objects embed-

ded in space. But they are denoted not by a single magnitude with an associated direction but by a constellation of numbers (or components) that transform linearly under transformations of the coordinates. They, however, remain unchanged when one applies a complete revolution about an axis. Finally, there is yet another form called pseudoscalar which also is an ensemble of numbers conforming to a set of restrictions on which I need not dwell here.

It appeared that beta decay interaction could be any of the aforementioned five possible forms. It could be scalar (S), vector (V), axial vector (A), tensor (T), pseudoscalar (P) or some simple combination of any two like  $V-A$ ,  $V+A$ ,  $S-T$ ,  $S+T$ . The empirical evidence available at the time was conflicting. Some observations favoured forms like A or T while others suggested  $V-A$  or  $S-T$ . Sudarshan chose the right form, the celebrated  $(V-A)$  interaction form, for reasons of symmetry physicists sometime invoke when in doubt. For, symmetry principle is often a physicist's heuristic



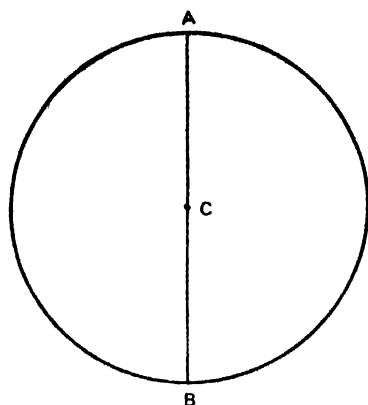
WEAK INTERACTION VIA EXCHANGE OF PARTICLES, NAMELY, WEAK VECTOR BOSONS



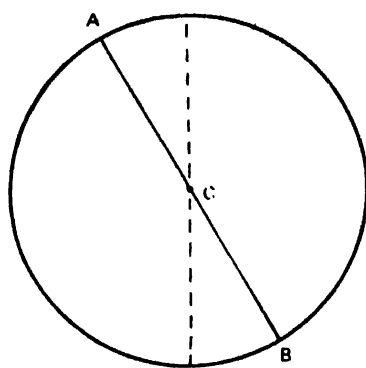
ELECTROMAGNETIC INTERACTION VIA EXCHANGE OF MASSLESS PHOTONS

Fig. 6



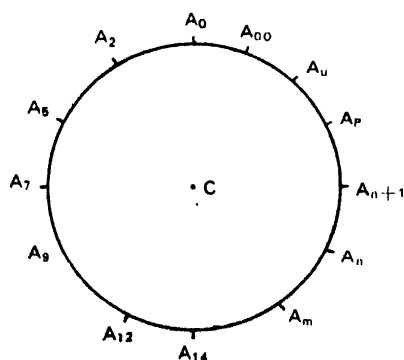


**Original circle**

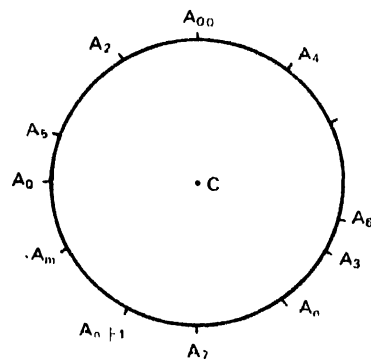


The circle after rotating any diameter ABC through the same angle about an axis through C perpendicular to the plane of the circle

**Global symmetry transformation**



Original circle broken into infinite bits  $A_1, A_2, A_3 \dots A_{\infty}$  of infinitesimal size



The same circle reconstructed by shuffling the infinitesimal bits independently but keeping their distance from the center C the same.

**Local symmetry transformation**

**Fig. 7**

guide to discovery of laws of nature. It reveals them by showing the unchanging core or reality beneath the changing facade of appearances. It does so by a subtle refinement of our everyday notion of symmetry that enables us to decide whether or not any given object is symmetrical. Thus an object like a spherical ball is called symmetrical because it looks the same after it is turned around through any arbitrary angle. More generally, a thing is symmetrical if

there is something you can do to it so that after you have finished doing it, it looks the same as before. In other words, the essence of symmetry is invariance or immutability of some aspect or feature of the thing. Sudarshan ventured to postulate a new principle of invariance to rationalise his choice of the mathematical form to describe weak interaction. It is called chirality invariance. The word "chirality" (pronounced kirality) was coined by Lord Kelvin

in 1884 and is derived from *cheir*, the Greek word for hand, which is indeed the most familiar chiral object. An object or a configuration of numbers is chiral if it cannot be brought into congruence with its mirror-image by translation and rotation. But if it can be so brought into congruence, it is called achiral. Familiar planar objects in the two-dimensional space of a printed page are capital block letters. Some of them such as A, B, C are two-dimensionally achiral. But others, for example, F, G, J are chiral since they cannot be brought in a plane into congruence with their mirror images (Fig. 4). The bold conjecture Sudarshan made was that the interaction forms of beta decay remain the same under any chiral transformation. They behave like the letters F, G, J rather than A, B, C. The remarkable consequence of this assumption is that the weak interaction form is now uniquely determined to be V-A. It effectively rules out any combination of the remaining three forms S, T, and P.

The Sudarshan-Marshak theory of weak interaction was further refined by Salam. Salam began his refinement by recalling that particle exchange can lead to attractive or repulsive forces. The idea may be illustrated by crude analogy shown in Fig. 5. Each child in the figure has a pillow. When the children exchange pillows by snatching them from each other's grasp, the effect is like that of a mutually attractive force. On the other hand, the children may also exchange pillows by throwing them at each other. Here conservation of momentum requires that the children move apart, just as if a repulsive force were separating them. Fermi used this analogy to interpret the electromagnetic force between two electrons as mediated by exchange of particles (pillows) called photons (Fig. 6, Right). A photon, by the way, is a mini packet of radiation of zero mass. It is also called a vector boson. In

## Salam and Science Reporter

**B**ESIDES being a great physicist, Prof. Abdus Salam is also an effective and interested science communicator. He brings science to laymen with as much ease as he explains his intricate theories to his research students. In writings and speeches, he is delightfully enjoyable.

His first article in *S.R.* was published in October 1966 issue with the title "Problems of advanced scientific research in developing countries". Sometime back, he had written the following letter to the Editor, *S.R.* :



INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS  
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DIRECTOR  
ABDUS SALAM

Dear Dr. Ambasta,

I am very pleased to receive copies of *Science Reporter*. It is a first-rate magazine and I was very happy to be able to see this. I was also delighted to see a paper on Elementary Particles by Dr. Bhowmik. This article contains essentially the material about which I may have written if I could. I shall certainly keep the magazine in mind, hoping that at some future date I can write for it.

With my very best regards and congratulations on the high standard you have set yourself.

Yours sincerely,

Abdus Salam

Dr. S.P. Ambasta  
Editor  
*Science Reporter*  
Council of Scientific  
and Industrial Research  
New Delhi  
India

exactly the same way the weak nuclear force is mediated by an analogue of the photon called the weak vector boson (Fig. 6. *Left*). But unlike the photon the vector boson must carry a unit positive or negative charge because a transfer of charge takes

place in radioactivity and charge is known to be absolutely conserved. Thus when the electrically neutral neutron in the nucleus of a radioactive atom changes into a positively charged proton, there is a transfer of one unit of charge. This

is why the mediating weak vector boson denoted by the symbol  $W^\pm$  is either positively or negatively charged unlike the electrically neutral photon often abbreviated as the Greek letter  $\gamma$ .

The charged weak vector bosons  $W^\pm$  are thus to weak interaction what the neutral photon  $\gamma$  is to electromagnetism. It is this analogy between weak vector bosons and photons which allows the two forces—electromagnetic and weak—to be unified in an all-embracing theory including both. Salam's unifying theory even predicts the mass of these particles  $W^\pm$  whose mediation gives rise to weak interaction. It is estimated to be around 80-90 times the mass of the proton even though their electromagnetic counterpart, the photon, is massless. Direct observation of these vector bosons is therefore the most crucial and convincing test of Salam-Weinberg theory. Unfortunately such particles cannot as yet be observed directly. They require for their observation particle accelerators much more powerful than any we have now. Their discovery must therefore await ten to twelve years required to construct and commission the accelerators of requisite power. Meanwhile experiments planned at CERN, the European countries centre for subnuclear physics, for 1982 are expected to provide some more overt evidence of their existence than any we have now.

Although the most crucial and stringent test of Salam's theory, the discovery of weak vector bosons, is yet to come, his theory did predict the existence of "neutral currents" five years before their actual observation in 1973. The term neutral current is a somewhat confusing epithet for weak interactions not involving the exchange of electric charge. For example, the familiar weak radioactive decay of atomic nucleus involves neutrons changing into protons (or *vice versa*) the excess charge being taken up by the creation

of an electron and an antineutrino (or their antiparticles). This is supposed to occur by the emission and reabsorption (or exchange) of a *charged* vector boson  $W^+$  or  $W^-$  between the nuclear and electron systems. Neutral current interactions, on the other hand, involve exchange of a neutral weak vector boson  $Z^0$  and so change protons into protons, electrons into electrons, and so on. Salam was led to postulate the existence of this neutral weak vector boson  $Z^0$  besides their charged counterparts  $W^\pm$  by symmetry considerations. For if weak and electromagnetic processes are basically alike, one must treat the photon ( $\gamma$ ) and weak vector bosons  $W^\pm$  as members of one family. Salam, however, showed that this is not possible unless there exists a fourth neutral vector boson  $Z^0$  to make the quartet. The detection of neutral current interactions mediated by the exchange of  $Z^0$  has proved extremely difficult because the weak force, being extremely weak, the effects of these neutral exchanges are completely masked by the analogous exchange of photons giving rise to electromagnetic force between charged particles such as an electron and proton. The first observation of neutral current was made in experiments with neutrinos (where electromagnetic effects are absent) at CERN; others followed cumulatively making an impressive body of evidence not only for the existence of neutral currents, but for the exact form of it predicted by Salam in his unified theory of 1968. More recently a brilliant experiment with polarised electrons at the Stanford Linear Accelerator Centre in California measured the interference between the electromagnetic and neutral weak interactions. The measurement is in complete accord with the prediction of Salam-Weinberg theory.

Salam believes that his theory is only a prelude to a grander programme of unification by recourse to

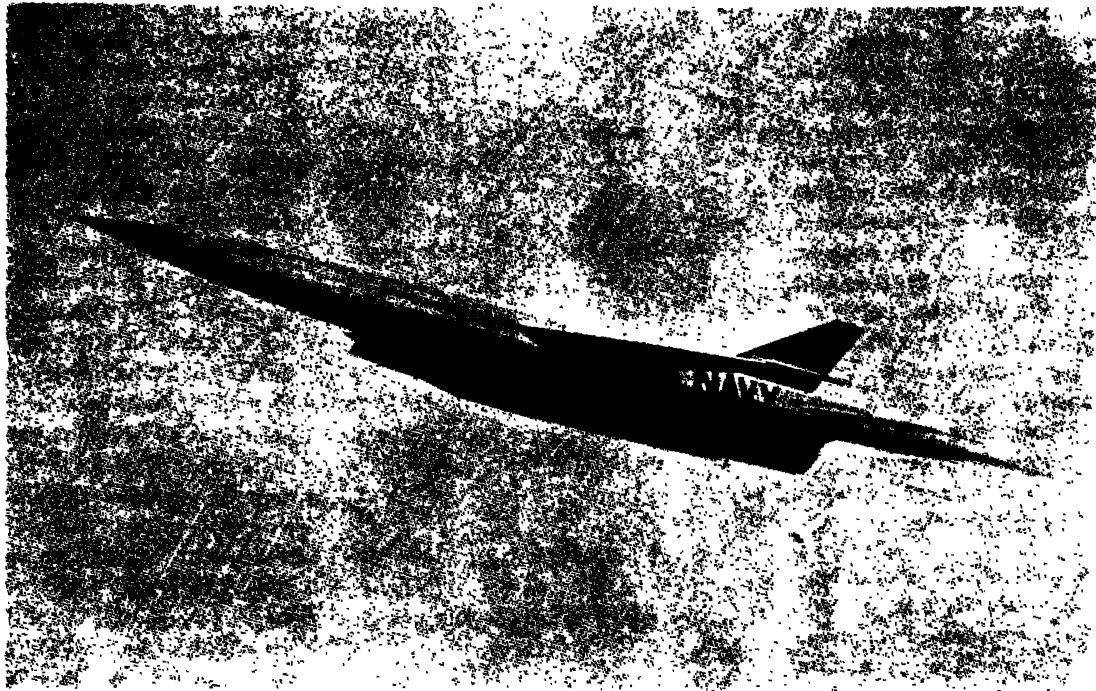
the so-called "gauge" principle. It is a principle first essayed by the celebrated mathematician, Herman Weyl, in a daring though unsuccessful bid to unify gravity and electromagnetism sixty years ago. Even though Weyl's attempt did not succeed, the principle underlying it remains valid. For it is based on symmetry considerations which have often guided physicists in formulating new physical laws. As noted already, symmetry is merely invariance or immutability of a thing after you have finished doing something to it. Now this "doing something to" or operation on the thing is one of two kinds. It may be a one-shot global operation or a piecemeal local one. A case in point of a global one-shot symmetry operation is the transformation of a circle by turning any of its diameters such as ABC through the same angle about an axis through its centre perpendicular to the circle as shown in Fig. 7 (*Top*). But if, on the other hand, each point on the circumference is moved piecemeal and independently by breaking the circumference into an infinite number of infinitesimal bits labelled  $A_1, A_2, A_3, \dots, A_n$  and then pushing or pulling the bits to new positions on the circumference while keeping their distance from the centre fixed, the circumference still retains its original form so that the procedure is again a symmetry operation as before (Fig. 7, *Bottom*). But it is now an instance of a piecemeal or local symmetry. A powerful general feature of the relation between global and local symmetries is the so-called "gauge" principle. It states that if a set of physical laws is invariant under a group of some global symmetry operation, the stronger requirement of invariance under local symmetry operation can be met only by introducing new fields which could be viewed as new forces. A well-known though naive instance of gauge transformation is provided by Maxwell's equations of electromagnetic pheno-

mena. It happens that these equations written in terms of field intensities or potentials are invariant under any change of space and time coordinates used to locate and date the events the equations describe. These coordinate changes which leave the equations unchanged or invariant are called Poincaré transformations. In other words, Maxwell's equations exhibit global symmetry under a group of Poincaré transformations. But it is also possible to add some function of space-time to the potentials without changing the invariance (or symmetry) of the equations. This new function of space-time has, of course, to obey certain well-defined restrictions. Its addition is thus equivalent to conserving the form, or equivalently invariance of the equations under *local* transformations. Besides, it retains its form also under one-shot global transformation we have called Poincaré transformation. The former is the analogue of the *piecemeal* transformation of the circle into itself of our earlier illustration of Fig. 9. The upshot is the emergence of a certain gauge or a kind of background norm against which the potentials are measured. We could, of course, interpret the new function as a field and the conditions which it satisfies as the field equations. Thus the choice of a particular gauge though it leaves the electromagnetic theory invariant, could be viewed as introduction of a new force which for all we know is as real as any we have known so far.

In general, the fields conjured by the introduction of local symmetry conserving operation are called gauge fields. These newly introduced fields are equivalent to the exchange of virtual particles or quanta like vector bosons and photons which give rise to corresponding force. It is by resort to such gauge fields that Salam has unified the weak and electromagnetic forces into one he

(Continued on page 213)

## FIBERGLASS IN DEFENCE



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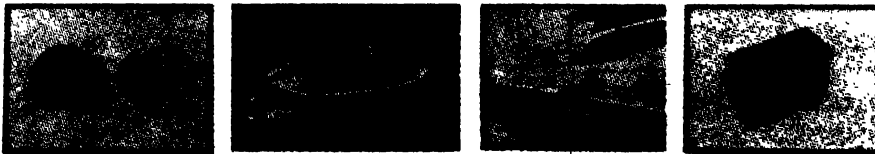
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UNTIL about 1932, only four particles, namely, the proton (p), the neutron (n), the electron (e) and the neutrino ( $\nu$ ) were regarded as the ultimate constituents of matter. Of these four particles, two, the proton and electron, are electrically charged. The other two are electrically neutral. The neutron and proton form atomic nuclei, the electron and nucleus form atoms while the neutrino comes out in radioactivity, i.e., the neutron decays into a proton, an electron and a neutrino. Each of these particles, called a fermion, spins and exists in two spin (or polarization) states called left-handed and right-handed spin states. These four particles experience four types of forces :

#### (1) The gravitational force

This is a force of attraction between any two particles and is proportional to their masses. It controls the motion of planets and galaxies and also governs the law of falling bodies. It determines the overall character of our universe.

#### (2) The electromagnetic force

It acts between any two charged particles, e.g., negatively charged electron and positively charged proton attract each other with a force which is proportional to their electric charges. It is responsible for the binding of atoms and mainly governs all known phenomena of life on earth. This force also manifests itself through electromagnetic radiation in the form of light, radio waves and X-rays. In other words, electromagnetic radiation is a carrier of electromagnetic force.

#### (3) The weak nuclear force

It is responsible for radioactivity and is principally responsible for the existence of heavy elements on earth and other parts of the universe.

**It is a physicist's dream to unify all the four seemingly different forces of nature. Abdus Salam and, independently, Steven Weinberg have succeeded in unifying the weak and electromagnetic forces**

#### (4) The strong nuclear force

This is responsible for holding the nucleus of an atom together.

Compared to the electromagnetic force, the weak nuclear force is weaker by a factor of one thousand, while the strong nuclear force is stronger by a factor of one hundred when these forces manifest themselves at the presently available energies. The gravitational force is the weakest of all— $10^{37}$  times weaker than the electromagnetic force. While the electromagnetic and gravitational forces are long range, the strong nuclear force is short range (it is effective when the neutron and proton are closer than  $10^{-13}$  cm); the weak nuclear force has a still shorter range (it is effective only when the particles undergoing this force are closer to each other than  $10^{-16}$  cm). In contrast to the strong nuclear and electromagnetic forces, the weak nuclear force can distinguish between left and right, i.e., it does not conserve parity.

We now know that the electron and neutrino are just two members of a family called leptons of which six are presently known to exist. Similarly, the neutron and proton are members of a much larger family called hadrons. Hadrons exist in two classes, baryons and mesons; the former carry half integral spin and a quantum number called baryon number while the latter carry zero or integral spin and no baryon number. The mass spectrum and production and decay characteristics of hadrons can be understood in a much simpler picture if one assumes that baryons are made of three constituents called quarks while mesons are made of quark and anti-quark pair. The quarks have spin one half (i.e. they exist in two spin states) and carry different flavours to distinguish them from each other. At present, five flavours, called up, down, strong, charm and bottom, are known to exist and the sixth one, called top, is strongly expected to be discovered. Quarks play the same role in hadron

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spectroscopy as the neutron and proton in nuclear spectroscopy and the electron and nucleus in atomic spectroscopy. To sum up, according to the present view, the quarks and leptons form the fundamental constituents of matter and they undergo the same four forces mentioned above, except that leptons do not experience strong nuclear force. These, according to the present view, are known as basic fermions, the ultimate constituents of matter.

Physicists would like to comprehend all natural phenomena in a unified way. It is a physicist's dream to unify all the four seemingly different forces of nature. Einstein tried hard to unify gravity with electricity, but failed. However, Abdus Salam, and independently, Steven Weinberg, have succeeded in a different kind of unification, namely, the unification of the weak and electromagnetic forces which we shall now describe.

As mentioned above, the electromagnetic force is mediated by electromagnetic radiation, the quanta of which are called photons. A photon is electrically neutral and is a spin one particle (called vector boson). Just as a photon mediates the electromagnetic force (or interaction), similarly, the weak nuclear force is mediated by weak vector bosons. Unlike the photon, weak vector bosons must carry a unit of positive or negative charge. This is because a transfer of charge takes place in radioactivity, for example, in  $\beta$ -radioactivity, the electrically neutral neutron changes into a positively charged proton, involving a transfer of one unit of charge. The photon is denoted by  $\gamma^\pm$  while the positively and negatively charged weak vector bosons are denoted by  $W^\pm$ . Now, as is well known, the electromagnetic force has associated with it the electric current. This current is coupled to the photon with the strength of electric charge  $e$ . Similarly, the weak nuclear force has associated with it two charged weak currents

coupled with the vector bosons  $W^\pm$ . Now, if there is to exist a basic unity between the electromagnetic and weak nuclear force, then one must treat vector bosons  $\gamma$ ,  $W^\pm$  as members of one family coupled, respectively, to electric and weak currents with equal basic strengths. It turns out, as was first noted by Salam and Weinberg, that one cannot do so unless there exists a fourth vector boson, which is electrically neutral and which is coupled to a new type of weak current called the neutral weak current. The fourth vector boson is denoted by  $Z^0$ . Then vector bosons  $\gamma$ ,  $W^\pm$ ,  $Z^0$  belong to one family and they are coupled to their respective currents with the coupling

strengths  $e$ ,  $\frac{e}{2\sqrt{2}\sin\theta_w}$  and  $\frac{e}{2\cos\theta_w}$

where  $\theta_w$  is a parameter of the theory. In other words, apart from the basic coupling strength, namely, the well known electric charge  $e$ , the theory contains only one parameter, namely,  $\theta_w$ . The vector bosons  $Z^0$ ,  $W^\pm$  must be massive since weak interaction is of short range, whereas the photon  $\gamma$  is massless and the theory itself provides a mechanism for the generation of these masses. Thus the Salam Weinberg theory predicted:

(a) That a new type of neutral weak interaction must exist. The existence of this interaction is necessary if there exists a basic unity between weak and electromagnetic forces in the sense that these two are forces two aspects of the same basic force.

(b) The theory has only one parameter, usually denoted by  $\sin^2\theta_w$  and all neutral weak interaction phenomena is describable in terms of this parameter; and,

(c) The vector bosons  $Z^0$ ,  $W^\pm$  should exist with well defined masses.

The year 1978 has seen a remarkable set of experiments confirming the Salam-Weinberg theory. Since neutrinos have only weak interaction, the simplest of experiments which detected the neutral weak interaction involves the scattering of neutrinos

on nuclei. These experiments have been reported by many groups at high energy physics laboratories in Europe, USA and USSR. All the predictions referred to in (a) and (b) above have been borne out by experiments. A neutral weak interaction has been discovered with the precise structure predicted by the Salam-Weinberg theory.

The Salam-Weinberg model received a convincing support in the experiments involving scattering of polarized electrons (when their spin is aligned in the direction of their motion or in the opposite way) on nuclei. Since according to this model, the weak and electromagnetic interactions are different manifestations of the same basic force and since weak interactions can distinguish between left and right, or do not conserve parity, this should imply that when charged particles interact through electromagnetic force, they should also be able to distinguish between the left and right or one should see minute parity violating effects. These effects should be particularly observable in those phenomena where the main parity conserving electromagnetic effect cancels out, e.g. in the difference of scattering cross-sections of right and left polarized electrons on unpolarized protons. Here the theory predicted a violation of parity of definite magnitude. The experiments done at SLAC in the USA with high energy polarized electrons on hydrogen and deuterium targets have detected the parity violation and that the left polarized electrons are scattered more than the right polarized ones as predicted by the theory. The resulting asymmetry is in accord with the Salam-Weinberg theory with  $\sin^2\theta_w = 0.2 \pm 0.03$  which is in complete agreement with its value from neutrino data.

The above value of  $\sin^2\theta_w$  gives the masses of three vector bosons  $W^\pm$ ,  $Z^0$  to be about 80–90 times

(Continued on page 169)

**W**HAT makes some plants grow better than others in a given place? Why do plants flower only in a specific season? How do climatic fluctuations affect plant growth? When do plants experience stress? Which season is most suited for a specific crop in a given area and which factor (s) determines the distribution of different plants in different zones? These and host of other intriguing questions

distribution of the continents, and a basic understanding of various facets of environment and different climatic zones of the world are essential for understanding the nature and distribution of various plants, both wild and domesticated. Basic knowledge of climatology assumes great significance while considering the intricate relationships between the climate and crops. Besides, a knowledge of the

several environmental factors like solar radiation, temperature, humidity, rainfall, wind, etc. These factors together are considered as 'environmental variables', which can be defined as "any aspect or fluctuations of which influence the plant at some stage during its life time". Each variable itself comprises different components. For example, the environmental variable 'solar radiation, is made up of components

# COMPLEXITIES IN CLIMATE-CROP RELATIONSHIPS

V. RAJAGOPAL  
K. KAILASANATHAN



Fig 1. Earhead of jowar

**India is a place to feel proud of as many well-known crops in the world originate here by virtue of the distinctly diverse nature of tropical climate**

have been confronting the plant scientists throughout the world for several decades. The answers to them would reveal much of the complexities involved in the climate-crop relationships.

A thorough recapitulation of the elementary knowledge of geographic

fundamental aspects of ecology and plant physiology is of further help in understanding the problem of climate-crop relationship in its entirety.

## Environmental variables

Plant growth is controlled by

like spectral composition, intensity, duration, direction, periodicity etc. So also, the variable 'temperature' comprises the degree, periodicity etc. The frequency, duration, distribution and direction are the components of the variable 'rainfall'. These environmental variables differ in their magnitude from one place to another depending upon the latitude, altitude, and so their effect on plant growth varies.

The importance of the environmental variables and their components varies depending upon the

objectives of the study. For instance, if one is interested to study the effect of radiation on the distribution of vegetation on a geographical scale, then the data on the mean annual radiation at different locations would be sufficient. On the other hand, for studying the influence of radiation on the growth and development of any crop throughout its life cycle, it is necessary to record the light intensities, spectral compositions, duration and direction of the sun angle in relation to the crop characteristics like leaf orientation etc., since each component has its own effect on plants.

#### Significance of environmental variables

**Solar radiation.** The vital factor determining the dry matter production in plants is solar radiation. Solar energy received at the surface of the earth is called 'insolation'. It differs from one place to another depending upon the latitude. The amount of solar energy received is fairly uniform throughout the year near the equator. A place like Singapore (Lat.  $01^{\circ}.21' N$ ) receives solar energy to the extent of 400-450 cal/cm<sup>2</sup>/day. At latitudes above  $50^{\circ}N$  the solar energy input varies considerably from one season to another. It can be as low as 50 cal/cm<sup>2</sup>/day in winter to as high as 450 cal/cm<sup>2</sup>/day on a clear summer day as in Britain. The insolation may be as high as 750 cal/cm<sup>2</sup>/day during long summer days in the subtropics of the Mediterranean region (e.g., Beirut, Cape Town, etc.). If the sky is overcast then the insolation may drop to 200 cal/cm<sup>2</sup>/day as it happens during summer rains in semi-arid tropics (e.g., Iran, Argentina, Zambia, etc.).

In India, the solar energy received during May exceeds 600 cal/cm<sup>2</sup>/day in places like Ahmedabad, Bhavnagar, Jodhpur, New Delhi and Pune, whereas it is less than 550 cal/cm<sup>2</sup>/day in Calcutta, Mangalore, Shillong, Trivandrum, Bangalore and Bhuba-

**Table 1. Difference in the components of solar radiation at intervals of time between a bright day and a cloudy day at New Delhi**

Parameters	Bright day (April)				Cloudy day (July)			
	8.00	10.00	12.00	14.00	8.00	10.00	12.00	14.00
Total radiation (Cal. cm <sup>-2</sup> . min <sup>-1</sup> )	1.14	1.58	1.32	1.29	0.53	0.86	0.80	0.67
PAR (Cal. cm <sup>-2</sup> . min <sup>-1</sup> )	1.08	0.89	0.76	0.72	0.32	0.59	0.55	0.52
Light intensity (Foot candles)	8361	9352	9836	8640	4134	6808	8194	5249

**Table 2. Annual rainfall pattern in different regions of the world and their characteristic features**

Range of annual rainfall (in millimetres)	Regions	Characteristic features
<b>(A) Humid tropics</b>		
(i) Above 2000	Triconamalle, George Town, Diego Garcia, Kuala Lumpur.	No dry season. Average monthly rainfall 100 mm.
(ii) —Do—	Central America, Chile, Northern Brazil	Definite dry period for few months.
<b>(B) Wet and dry tropics</b>		
(iii) Between 1500 and 2000	Burma, North Vietnam, Cambodia.	One season with exceptionally heavy rainfall and a long dry season.
(iv) 1000 to 2000	Ethiopia, Southern Sri Lanka, North Malaysia.	Short dry season.
(v) Between 500 and 1500	Thailand, Tanzania, Venezuela	A pronounced dry season in between two short rainy seasons.
(vi) —Do—	China, Kenya, Southern Brazil, Southwest and Southeast Australia, Zambia.	A long rainy season and a long dry season.
(vii) Between 250 and 650	Mexico, Northern Argentina, Rhodesia, Turkey, Iran, Afghanistan.	One short rainy season and a long dry season.
<b>(C) Dry regions</b>		
(viii) Less than 300	Southwest Africa (Namibia), Sudan, Egypt, Saudi Arabia, Southern Argentina, Peru. Western Australia.	Little rainfall only for few weeks.

neshwar. The insolation during the Bangalore and Hyderabad. It is rainy months of July-September is less than 300 cal/cm<sup>2</sup>/day in Mangalore. In Jodhpur and New Delhi the like Bhavnagar; Calcutta, Goa, winter months, December-January, Nagpur, Pune, Shillong, Vizag., register solar radiation less than 350



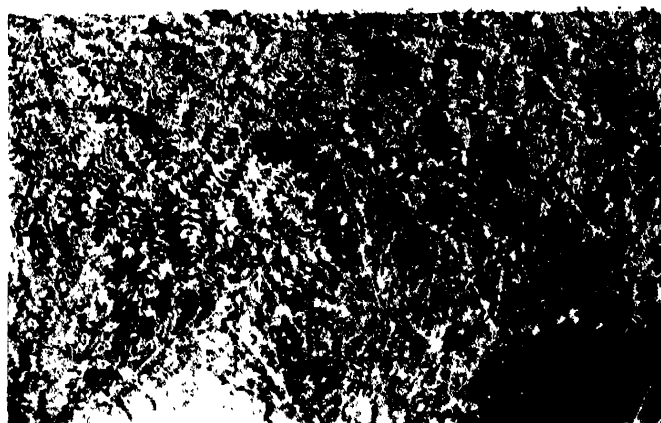


Fig. 2. Low photosynthesis plants : wheat (*Triticum aestivum*) (Top Left); gram (*Cicer arietinum*) (Top Right); cowpea (*Vigna unguiculata*) (Bottom Left); High photosynthesis plant : maize (*Zea mays*) (Bottom Right)

cal/cm<sup>2</sup>/day. While in most parts of the country the variations are in the range of 300 and 550 cal/cm<sup>2</sup>/day, in places like Srinagar it varies from 170 cal/cm<sup>2</sup>/day during December-January to as high as 643 cal/cm<sup>2</sup>/day in May. Table 1 gives data on different parameters collected at New Delhi. It is clear that solar radiation components differ not only in different seasons but also during different time intervals of the same day in a season. The amount of clouds as well as their movement influence the accuracy of measurement of these parameters.

Another equally important consideration is the 'total sunshine hours' which also vary depending upon the latitude. On a global scale, Amman

(Jordan) has the highest annual total sunshine hours (3590), followed by Cairo (3504), Jerusalem (3474) and Baghdad (3244). It can be as low as 1782 hours (Copenhagen) and 1465 hours (Warsaw). In India, Jodhpur has the highest sunshine hours (3274), followed by Ahmedabad (3144) and Allahabad (3128), whereas New Delhi, Hyderabad and Nagpur receive sunshine in the range of 2800-2900 hours; Bombay, Pune and Madras 2700-2800 hours and Bangalore 2400 hours.

Interestingly, the maximum sunshine hours at different places occur in different months: in June at Jerusalem (412), Washington (294) and San Francisco (323); in July at Amman (407), Cairo (360), Madrid

(383), Ankara (384) and Kabul (352) or sometimes even in August as at Baghdad (354). There are also places where maximum sunshine occurs in December-January like Perth (324), Sydney (233), Buenos Aires (293) and Addis Ababa (275).

In India, sunshine hours are maximum in March at Calcutta (264), Madras (304) and Bangalore (282); in May at Jodhpur (326); Allahabad (294) and Ahmedabad (338); or even in October as at New Delhi (288) or in January as at Hyderabad (307). However, from the crop productivity point of view it is the total sunshine hours during the actual crop growth period like 'kharif' (June-October) and 'rabi' (November-March) that is most

**Table 3. The rainfall pattern in India**

Range of annual rainfall (in millimetre)	Regions	Characteristic features
(i) Above 2000	Bombay, Goa, Cochin, Mangalore	Assured rainfall areas. Covers 28% of the total area.
(ii) Between 1250 and 2000	Nagpur, Belgaum, Cuttack, Calcutta, Gauhati.	- Do -
(iii) Between 750 and 1250	Hyderabad, Agra, Ahmedabad, Akola, Allahabad, Indore, Madras.	Covers 42% of the total area.
(iv) Between 250 and 750	Bikaner, Jodhpur, Bellary, Anantapur, New Delhi, Sholapur.	Covers 30% of the area.

**Table 4. Seasonal changes in radiation and the conversion efficiency of crops at New Delhi**

Parameters	Kharif		Rabi	
Total radiation (K. Cal. cm <sup>-2</sup> )	55.4		60.3	
PAR (K. cal. cm <sup>-2</sup> )	35.1		31.6	
	Maize	Pigeonpea	Wheat	Chickpea
Biological yield (Dry matter, tons. ha <sup>-1</sup> )	19.1	10.2	20.1	9.2

Courtesy : Prof. S. K. Sinha and Sri K. Kailasanathan, Water Technology Centre, I.A.R.I., New Delhi 110012.

important rather than the annual total. The relationship between sunshine hours and the yield of rice varieties has been reported earlier (S.R., April 1979, p. 256).

The length of the day (from sunrise to sunset) also changes from one place to another depending upon the latitude and season of the year. At the equator the day length is nearly constant (12 hours) throughout the year, whereas at high latitudes it varies considerably with the season. For instance, near the poles the day length could be almost 22 to 24 hours during mid-summer (midnight sun in Norway) while during mid-winter it is almost near 0 hour ('dark' day time in Norway).

**Temperature.** Like solar radiation, temperature also varies depending upon the latitude and altitude. The

variation in temperature follows the variation in the incident solar energy. With increase in altitude the temperature decreases. For example, at Darjeeling (altitude 2127 meters) the mean annual temperature is 13.3°C whereas at New Delhi (216 meters) it is 25.3°C. There is little variation in temperature between seasons (summer and winter) and between day and night in the equatorial belt. For example, a daily maximum of 25°C to 27°C occurs at Kuala Lumpur, Manila, Jakarta and Georgetown; 28°C to 30°C at Rangoon and Trincomalee or 35°C in Khartoum. But, to the north and south of the equator both seasonal and daily fluctuations in temperature are large. In January the mean temperature is between 7°C and 10°C and during July between 24°C to 35°C [Rome (8°C/25°C), Baghdad

(10°C/35°C), Amman (8.2°C/25.2°C), Peshawar (10.7°C / 32.6°C) and Damascus (7.7°C/27.2°C)]. In India we find large differences in temperature between January (10°C to 15°C) and July (30°C to 38°C) as at New Delhi (14.3°C/31.2°C), Ludhiana (13.0°C/31.3°C), Bikaner (13.6°C/33.3°C), etc. In places like Bombay (24°C/29°C), Belgaum (22°C/27°C), Mangalore (26°C/29°C) and Bangalore (20°C/27°C) the temperature differences between seasons are less than 10°C.

**Rainfall.** Rainfall is another important factor that determines the overall crop growth and yield. Different regions in the world can be grouped on a broader scale taking into account not only the total amount of annual rainfall but also the intermittent dry periods, though it is difficult to place any region strictly in a particular division because of the variations in rainfall pattern. The same region or country shows more than one pattern (Table 2).

In India four levels of rainfall can be recognised (Table 3), 74% of the rainfall is through South-West monsoon (June-October), while only 16% is received through North-East monsoon (October-January). In addition, 10% of the rainfall is received during pre- and post-monsoon seasons.

#### Physiological significance of the climatic factors

**Solar radiation.** All the components of solar radiation, namely, spectral composition, intensity, duration, direction and periodicity have direct effect on various physiological and biochemical processes in plants. Light regulates many processes like seed germination, leaf enlargement, pigmentation, flowering, plant movements, etc. These photoregulated responses are mediated through different pigment systems. The absorption of solar energy by the pigments and its conversion into chemical

## Climatic and vegetational zones

### Climatic zones

THE word 'climate' represents the changes in the environmental variables over space and time. It should be noted that the 'regional climate' of the locality or zone might differ from the 'local climate' of the habitat because the latter is influenced by the plant community growing in the vicinity. Based on changes in the climate on a global scale five distinct zones called "climatic zones" can be recognised:

(i) *Tropical zone*—lying between about 30°N and S of the equator, is characterised by rainy season in the summer and a dry season in the cool months. Greater the distance from the equator, longer is the duration of the dry season, e.g., Ethiopia, Northern Australia, South and Southeast Asia, Congo and Central America.

(ii) *Sub-tropical dry zone*—lies poleward of 30° N and S. Very low rainfall and intense solar radiation resulting in high day temperatures are the characteristic features of this zone. In winter months temperature may drop to near 0°C during nights. This zone is represented by Lebanon, Chile, Southern Africa, etc.

(iii) *Temperate zone*—There are three distinct sub-zones: (a) warm temperate climate (humid temperate)

with wet summer and no winter, e.g., Southern Japan, (b) typical temperate climate (semiarid temperate) with cold but short winter as in Central Europe and coastal and north-eastern America, and (c) arid temperate with summer and winter showing large temperature differences as in Southern Europe and Eastern Asia.

(iv) *Boreal zone*—is characterised by cold, long winter and wet, cool summers, e.g., North America and Northern Europe, and

(v) *Arctic zone*—in this zone summer is short and wet with low temperatures, but winter is long, cold and dark, e.g., Canada and Siberia.

In India, we can find both tropical and sub-tropical climates. However, within tropical zone humid climate occurs along the west coast and the eastern parts above Orissa and semi-arid climate through most of the lower central and southern states. Sub-tropical zone is restricted to upper central and the entire northern states with humid climate, whereas the western states (Rajasthan and parts of Gujarat) with semi-arid and arid climate (Fig. 3).

### Vegetational zones

THERE are characteristic vegetational zones coupled with climatic zones.

(i) *Tropical ever-green rain forest zone*: South America, Africa (Guinea Coast, eastern Malagasy) and Asia (Malaysia, Indonesia and the Philippines).

(ii) *Tropical moist and dry deciduous forests*: Greater part of Africa and large parts of Australia.

(iii) *Sub-tropical deserts and semi-deserts*: Found in S.W. America, N. Africa, Sahara, Libyan and Arabian deserts.

(iv) *Sclerophyllous forests*: These forests occur in greater part of the Mediterranean Coast, Central and Southern California in U.S.A. Central Chile, Southern Cape in S. Africa and Southwestern Australia.

(v) *Warm-temperate, wet ever-green forests* are seen extensively in Eastern Asia, Southern east coast of Australia and North Island of New Zealand.

(iv) *Deciduous forests of the temperate zone*: Under this zone fall large areas of Eastern North America, Western and Central Europe and East Asia.

(vii) *Boreal coniferous zone* is found in the Northern part of North America and Eurasia.

In India, the deciduous tropical forests are well represented. The richness of floral vegetation and the need to conserve them has been vividly described in *S.R.*, May 1979.

energy involves intrinsic biochemical processes. It is a known fact that the amount of radiation absorbed by a leaf depends upon the wavelength and spectral characteristics. Visible light is absorbed most effectively by chlorophyll pigments in the blue (400 nm-500 nm) and red (600 nm-700 nm) regions of the spectrum (1 nm=10<sup>-9</sup>m).

Plants show variations in their efficiency to fix atmospheric CO<sub>2</sub> using the solar energy. All plants do

not make use of the incident radiation. The leaves of some plants (rice, wheat, gram, etc.) are saturated at intensities below full sunlight, while those of others (sorghum, maize, sugarcane, etc.) effectively make use of strong light intensities. The former are grouped under 'low photosynthesis' (Fig. 2, *Top*) and the latter under 'high photosynthesis' (Fig. 2, *Bottom*) plants. Also, only some plants (tomato, sunflower, tobacco, soybean, etc.) can grow better under full sunlight,

while others (oxalis some ferns) are shade-loving. The tolerance level of one group of plants under a different light situation varies widely. Thus, ecological distribution of plants are determined by light factors.

From the crop productivity point of view, the photosynthetically active radiation (PAR) has greater significance than the total radiation. Crops differ in their radiation conversion efficiency. The biological yield of crops depends on the seasonal changes

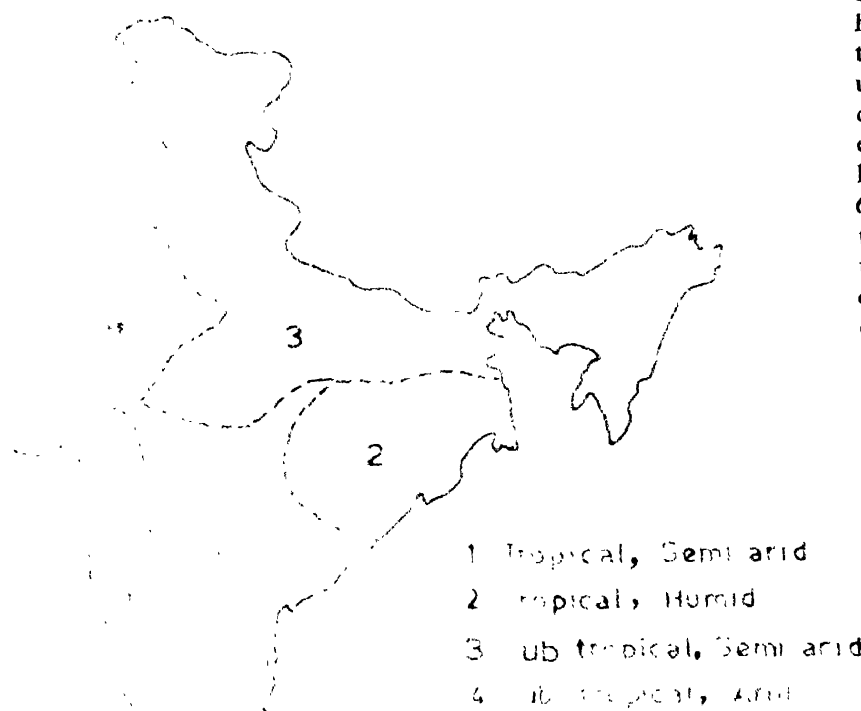


Fig. 3. Map showing the climatic zones in India (After Heinrich Walter 1973)

in the total radiation and the PAR. From Table 4 it can be seen that the two main crop seasons *kharif* and *rabi* differ in their total radiation and PAR. Biological yield of a cereal crop and a legume crop in each season reflects its radiation conversion efficiency. Both maize and wheat are more efficient than the legumes, though grown at two different seasons. The physiological implications of such performance of crop communities are being worked out at the Water Technology Centre, I.A.R.I., New Delhi.

The quality of light, i.e., its spectral composition, determines the chemical substances produced by plant cells. Red light has been shown to increase carbohydrates while blue light favours the accumulation of proteins. As the spectral composition changes from dawn to dusk, the plant products also vary depending

upon the time of the day. Formation of sugar compounds increases with increasing time from morning to evening (see also S.R., April 1979).

**Temperature.** The rate of growth of crops is influenced greatly by the changes in temperature. Temperature influences the important stages of crop growth commencing from seed germination to vegetative and reproductive growth through grain or seed formation. For instance, the utilization of seed reserves for the growth of shoots and roots has been found to vary not only between different crops (wheat, barley, maize, sorghum, cowpea, etc.) but also between different varieties of the same crop. Another common observation is the delayed flowering of cowpea, soybeans, etc., during cool nights. Tea and coffee are more productive under cool tropical highlands.

In rice crop the ripening period

is dependent on temperature—the higher the temperature the shorter is the ripening period. For example, under tropical conditions ripening occurs within 30 to 35 days (after the emergence of panicle), whereas at low temperatures it may prolong to 60 days. In fact, the entire crop duration in rice is controlled by temperature. Wheat grown in different parts of India ripen during different months: end of February or early March in Central India, in April in U.P., in May in Punjab or even in June in Northern hills. This again indicates the close association between the rapidly increasing temperatures and the early maturity of the crop in these areas.

Mention also must be made of the existence of unusual situations like the association between cool temperatures and tropical day length and solar energy. The mountains in the tropics near the equator as in East Africa (Mt. Kenya and Kilimanjaro) provide a good example. In these areas it is possible to grow a combination of both temperate and tropical crops like tea, coffee, wheat, maize, bananas, sweet potato, etc. But not all temperate crops can be grown in the tropics because in many temperate species low temperature has an important effect on processes like induction of flowering, breaking of seed dormancy, etc.

Different stages of growth have different temperature optima; in wheat for example it is 10°C to 15°C during seed germination and vegetative growth and 30°C to 35°C during grain forming stages. Also, different processes exhibit different optimal temperature requirements. For instance, at a temperature around 20°C the photosynthesis may be at a higher rate than respiration. Even the day-night temperature fluctuation plays a great role in several physiological processes. Rice grown at a day/night temperature of 26°C/23°C took 84 days to flowering, whereas a shift in temperature regime to 30°C/21°C

**Table 5. Plants which had their origin in India (After J.W. Purseglove, 1968 and 1972)**

Botanical name	Common name	Use
<i>Artocarpus heterophyllum</i>	Jack fruit	Edible fruit
<i>Amomum aromaticum</i>	Bengal cardamom	Spice
<i>Brassica campestris</i>	Field mustard	Oil seed
<i>Cassia fistula</i>	Indian laburnum	Purgative
<i>Cinnamomum tamala</i>	Indian cassia	Spice
<i>Coffea bengalensis</i>	Coffee	Beverage
<i>Crotalaria juncea</i>	Sunn hemp	Fibre
<i>Cucumis sativus</i>	Cucumber	Salad vegetable
<i>Curcuma angustifolia</i>	India arrowroot	Medicinal
<i>Cyamopsis tetragonoloba</i>	Cluster bean	Edible pods
<i>Ficus bengalensis</i>	Indian banyan	Ornamental
<i>F. elastica</i>	Indian rubber fig	Rubber
<i>Indigofera tinctoria</i>	Indigo	Dye
<i>Murraya Koenigii</i>	Curry leaf	Flavouring
<i>Oryza officinalis</i>	Wild rice	Weed
<i>O. sativa sub-sp. 'indica'</i>	Tropic rice	Cereal
<i>Phaseolus mungo</i>	Blackgram	Pulse
<i>P. aconitifolium</i>	Mat bean	Pulse
<i>Piper nigrum</i>	Pepper	Spice
<i>Saccharum barberi</i>	Sugarcane	Sugar
<i>Sesamum prostratum</i>	Sesame	Oil seed
<i>Solanum melangena</i>	Egg plant	Vegetable
<i>Sorghum durra</i>	Durra	Cereal
<i>Sterculia urens</i>	Kataya gum	Gum
<i>Triticum aestivum sub-sp. sphaerococcum</i>	Wheat	Cereal

**Table 6. The range of latitude and temperature variation during the growth of some important crops (After J.W. Purseglove, 1968, 1972 and S.K. Sinha, 1977)**

Botanical name	Common name	Latitude	Temperature
<i>Arachis hypogaea</i>	Groundnut	40°N-40°S	20°-38°C
<i>Cajanus cajan</i>	Red gram	30°N-30°S	20°-40°C
<i>Cicer arietinum</i>	Bengal gram	15°N-40°N	10°-30°C
<i>Cocos nucifera</i>	Coconut	20°N-20°S	27°-32°C
<i>Gossypium sp</i>	Cotton	37°N-32°S	20°-35°C
<i>Musa paradisiaca</i>	Banana	30°N-30°S	27°-30°C
<i>Oryza sativa</i>	Rice	45°N-40°S	20°-38°S
<i>Pisum sativum</i>	Green peas	25°N-40°S	10°-30°C
<i>Saccharum officinarum</i>	Sugarcane	35°N-35°S	32°-38°C
<i>Sorghum bicolor</i>	Jowar	40°N-40°S	30°-35°C
<i>Triticum aestivum</i>	Bread wheat	60°N-	20°-35°C
<i>Zea mays</i>	Corn	50°N-40°S	25°-30°C

resulted in delayed flowering (118 days). A day temperature of 26°C and a night temperature of 17°C was found to be the best for tomato fruit development. The plant parts differ in their temperature requirement for growth—shoots grow at higher temperatures than the roots

for example. So, the climatic factors significantly influence crop productivity, which in turn is the manifestation of various physiological and biochemical processes

#### Origin and distribution of crop plants

Several considerations like lati-

tude, altitude and the prevailing environmental factors contribute to determining the origin of plants. Adaptation to a given situation leads to diversity in the distribution of plants in different parts of the world. There are geographically different races of the same crop which have evolved as a result of diversity in the nature of climatic zone. The best example is provided by rice (*Oryza sativa*). There are three sub-species of this crop which have different geographical distribution. For instance, the 'indica' rice is adapted to tropical monsoon climate (South and Southeast Asia and the Philippines); 'javanica' rice is adapted to equatorial climate and is mainly grown in Indonesia; 'japonica' rice is adapted to temperate climate and is grown in Japan, S. Korea, N. China, S. Europe, etc. These three sub-species differ not only in their duration of crop growth, morphological characters (plant height, tiller number, leaf and ear characters, grain shape, etc.) and their response to photoperiod, but also in their yield potential and the price command. 'Indica' rice is usually very sensitive to photoperiod while other two are not. Though the yield potential of 'indica' is considered to be lower than 'japonica', the price command is higher for the former.

By virtue of its widely varying climatic regions, India has the distinction of being the land of origin of many well-known crops in the world (Table 5). Table 6 gives an idea about the wide distribution of different crops on a global scale and also the optimum temperature conditions for their growth.

The renowned Russian Botanist N. L. Vavilov has listed the centres of origin of different crops. China was the origin for soybean, while sugarcane, coconut, bananas etc., have originated in the Indomalaysian peninsula. Crops like wheat, rye, barley, and chickpea came from the near and middle east. The Ethiopian

region is considered as the origin for sorghum, pearl-millet, finger millet, cowpea, arabica coffee, etc., whereas maize, upland cotton and tomato came from South America. This general account gives an insight into the climatic conditions of the zones where different crops originated. The wide distribution of these crops in different climatic zones, as we find them today, indicates the range of their adaptability.

Historical evidences coupled with ecological considerations and systematic botanical relationships have helped in tracing the origin of important crops, whereas the cultivation pattern of wild species to suit to the needs of the ancient food-hunters who migrated from place to place through centuries reveal the crop migration from its place of origin to different areas. For example, the widely accepted opinion is that rice was domesticated in India or Indochina, but was later taken by people from Southern China to the Philippines. Likewise, from China it spread to Japan. Not until the conquest of India by Alexander the Great in 320 B.C. was rice found in Europe.

It spread westwards to Iran between 400 B.C. and 300 B.C. and later to Syria. Rice was introduced in to Brazil by the Portuguese.

The foregoing account shows the complex nature of the relationship between the climate and crops. It not only provides an opportunity to learn about the origin of crops but also about the greater potentiality of harnessing their yield by exploiting the favourable environmental variables, like abundant sunshine. This is what the modern agriculturists are precisely attempting to do with the ultimate motive of attaining the maximum yield potentials. The latest thrust is on the maximization of solar energy utilization. Crops are being screened for their radiation conversion efficiency.

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## UNIFICATION OF WEAK AND ELECTROMAGNETIC FORCES (Continued from page 161)

the mass of the proton. The experimental verification of the existence of these bosons will have to await ten to twelve years till particle accelerators of requisite energy are commissioned and constructed.

There is now no doubt that the weak nuclear force is nothing but a different facet of a basic force whose other facet is electromagnetic force.

The unification of two seemingly different forces, namely, of weak and electromagnetic, has justly been described as analogous to the nineteenth century unification of electricity and magnetism obtained by Faraday and Maxwell. It is an idea of profound importance. Its importance is comparable to that of Newton's theory of gravitation which showed that the force responsible for a falling

object is the same as that which keeps the planets in their orbits.

The Salam-Weinberg theory reduces the four fundamental forces in nature to three, namely, the strong nuclear forces, the electro-weak force and gravity. This success may help in achieving a unification of these three forces, the ultimate dream of a physicist.

**I**N his memorable lecture given before the South Indian Science Association at Bangalore on 16th March 1928, Prof. C. V. Raman described his discovery of 'A new type of secondary radiation' which he had come across a few days earlier at the laboratories of Indian Association for the Cultivation

quantum theory of radiation put forward by Max von Planck and extended by Albert Einstein according to which a body can give out or take up energy only in integral multiples of a definite amount.

Raman effect is a phenomenon which occurs when light is scattered

physicist. Raman effect is, in fact, an optical analogue of Compton effect. As scattering of light itself was known by A. Smekal, Raman effect is also called Smekal-Raman effect. Scattering of light in gases was known even in the last century. Lord Rayleigh interpreted the blue colour of the sky as

## S. RAMAKRISHNAN

**16th March 1980 marks the 52nd anniversary of the discovery of Raman effect. Today, it finds applications in not only physics and chemistry but also in many other scientific disciplines**

of Science, Calcutta. That discovery won for him universal applause and acclamation of scientists all over the world for its fundamental and far-reaching nature, and later for its multifarious applications in science and industry, technology and biology.

Raman effect came into the scene as a result of patient and persistent work of Raman in collaboration with other scientists, namely, S. Bhagavantam, K. R. Ramana-  
than, K. S. Krishnan and others. Because of its universality in nature and applicability in the three states of matter it opened a very wide field for research. Raman effect thus marked an era in the progress of science in general and modern physics in particular. It provided perhaps one of the most convincing justifications for the

by matter of any kind—solid, liquid or gas. It is a specific and characteristic change in the frequency of light introduced during light-scattering by molecules of substances in solid, liquid or gaseous state.

The phenomenon of scattering has been known for a long time. Scattering of X-rays and gamma rays is known as Compton effect after A.H. Compton, the American

due to the scattering of sun's rays by molecules of air. Raman himself remarked that he drew his inspiration from Compton effect and Rayleigh's interpretation of the blue skies. He observed that "the inspiration for this scheme of research was derived in the first instance from Rayleigh's well-known theory of the blue sky and the hope that our laboratory studies would furnish a

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solid experimental basis for the explanation of such natural processes as the colour of the sea and the colour of ice in glaciers."

### What is Raman effect ?

The greatness of Raman's discovery lies in his concept of a new type of secondary radiation. He observed that during scattering, the colour of the light itself is altered (in most cases) by the molecules. This change in colour attending the scattering of light is the Raman effect.

Now the question arises : Why does the colour change due to scattering ?

According to modern ideas of quantum theory of radiation, a beam of light is supposed to be propagated through space as what are called energy quanta or photons, which are not propagated continuously but in integral multiples of a definite amount. The photons decide the colour of the light.

When a photon hits a molecule, it may be scattered without change of energy or it may give up a part of its energy to the molecule and be scattered with less energy. In rare cases, it may also absorb a certain amount of energy from the molecule and be scattered with more energy. Where the energy of a photon does not change, no colour change occurs, but where there is energy change, the colour is altered towards the red or violet end of the spectrum. One point to be noted here is that there is no question of exchange of energy between the molecules and photons. Every molecule has a scheme of energy levels peculiar to it, and it can either accept or give up an amount of energy equal to what is needed to transfer from one level to another. Obviously, therefore, if we can measure the changes in the energy of the photons due to scattering, we obtain at once the scheme of energy levels of the molecules. In order to be able to measure the change in

energy of photon, it is clearly necessary to use only photons of definite energy to start with, i.e., a single coloured light. When such monochromatic light is examined in a spectroscope, only a small number of sharp lines is observed. But when such light falls on a liquid or any other substance and the scattered beam (usually at right angles) is examined, many new lines are seen which are called Raman lines; the spectrum as a whole is called Raman spectrum, (Figs. 1 to 3) which is specific and characteristic of the scattering substance. By measuring the difference between the energy of these Raman lines and that of the initial lines due to incident light, the energy levels of molecules of the scattering substance can be obtained.

To put Raman effect in physical language, when the molecules of solid, liquid or gas are irradiated with monochromatic light, that is, light of definite frequency, the quanta of energy or photons of light interact with the molecules and a part of their energy may be distributed throughout the molecules in their vibrational and rotational degrees of freedom. Energy not used in these vibrational and rotational excitations is scattered from the molecule as light of different frequency. Thus additional lines of altered frequencies are seen. The additional lines are characteristic of the scattering substances.

If  $\nu_i$  is the frequency of the incident light and  $\nu_s$  that of the scattered light, then from quantum theory, the energy associated with the incident and the scattered rays is  $h\nu_i$  and  $h\nu_s$  respectively. The energy difference which has been presumably transferred to the molecule of the substance is equal to  $h(\nu_i - \nu_s)$ . The frequency difference,  $\nu_i - \nu_s = \Delta\nu$ , is called Raman frequency.

### Applications

The first application of Raman effect is in the elucidation of mole-

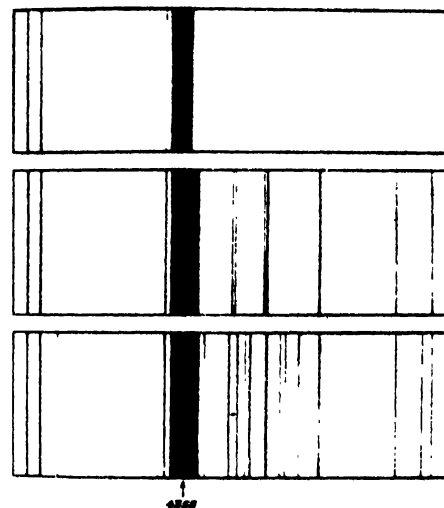


Fig. 1. Raman spectra of benzene and toluene; Top: incident spectrum, Middle: Benzenes cattering, Bottom: Toluene scattering

cular architecture. An examination of Raman spectra of many compounds has shown that  $h\Delta\nu$  is almost invariably equal to the change in rotational and vibrational energy of the molecule. So the information obtained from Raman spectra helps in knowing about the vibrational and rotational levels of the molecules and thereby in the elucidation of the molecular structure. The vibrational and rotational transi-

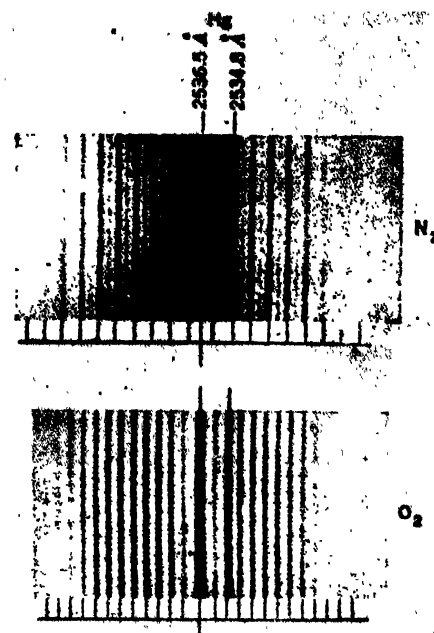


Fig. 2



# FREQUENCY ASSIGNMENT CHART FOR RAMAN SPECTRA

GROUP	TYPE	0	400	1200	2000	2800	3600
C—C							
C=C	ETHYLENIC						
C=C	CONJUGATED						
C=C	AROMATIC						
C=C=C							
C—H	ACETYLENIC						
C—H	ETHYLENIC						
C—H	AROMATIC						
C—H	ALIPHATIC						
CH <sub>2</sub>							
CH <sub>3</sub>							
C=O	ESTER						
C=O	ACID						
C=O	KETONE & ALDEHYDE						

tions give a band of spectrum which lies mainly in the near infrared. A diatomic molecule has only one set of such bands whereas for a polyatomic molecule several sets are observed. So, from the sets of observed bands one can have an idea about the modes of vibration.

From the modes of vibration, it is possible to know whether the

molecule is diatomic or triatomic, etc., and also the stereochemical arrangement of atoms in the molecule. From the study of Raman spectra it has been shown that molecules of water, hydrogen sulphide, sulphur dioxide, etc., are triangular, those of ammonia are pyramidal and those of phosgene, thionyl chloride are Y shaped.

A second application of Raman effect is in determination of the interatomic distances. If a molecule is regarded as a simple harmonic oscillator, its energy is restricted by quantum considerations to integral multiples of  $h\nu$ . From an equation relating the frequency ( $\nu$ ) and the moment of inertia of the molecule ( $I$ ), the latter can be calculated. The moment of inertia of a molecule is related to the interatomic distance ( $d$ ) by the equation

$$I = \frac{m_1 m_2}{m_1 + m_2} \times d^2$$

where  $m_1$  and  $m_2$  are masses of the atoms involved. From this the interatomic distance ( $d$ ) in a molecule can be calculated. The internuclear distances in hydrogen chloride, benzene, etc., have been calculated using this equation.

A third application of Raman effect in chemistry is in determination of strength of linkages. From Raman spectra the force constants,

viz., restoration force per centimeter in the molecule, can be calculated. These constants give the relative magnitudes of forces involved in various chemical valency bonds and thereby the strength and multiplicity of linkages. The force constant is proportional to the number of electron pairs shared by two atoms. This apparently holds good for covalent bond as well as coordinate bond which shows that there is really no fundamental difference between covalency and coordinate covalency.

Not only the strength of linkages but the nature of groups present in the molecule can also be known because particular groups have fixed force constants. For example, force constants can be employed to know whether the molecule has a C—C or C=C or C≡C bond.

There is also a direct method of identifying functional groups and bond multiplicity by Raman spectra. The characteristic frequencies of Raman lines are useful in this respect (Table 1). The vibration frequencies determined from spectra are those of the different modes of vibration of the molecule as a whole. However, force constants of certain linkages often have a predominant influence on a particular frequency. So, that particular frequency may be regarded as being due to a particular bond or linkage. It has become the practice

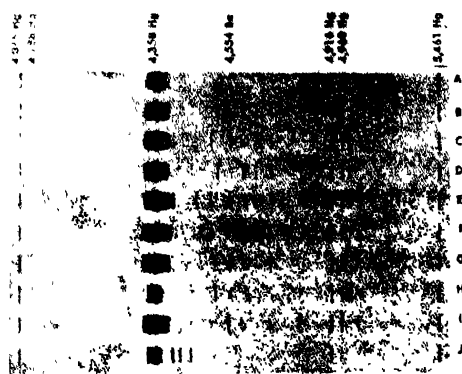


Fig. 2. Examples of Raman spectra taken with the Hilger Raman spectrograph. The wavelengths of the several mercury lines and of one faint line of barium (from the filament coating in the mercury lamps) are marked for identification. The spectra are: (A) Light source-only; (B) *o*-(20 per cent) and *p*-xylene (80 per cent); (C) mixture of 15 per cent *o*-xylene, 56 per cent *m*-xylene, 8 per cent *p*-xylene, 17 per cent ethylbenzene, 1 per cent toluene and 2 per cent styrene; (D) *p*-xylene; (E) *m*-xylene; (F) *o*-xylene; (G) ethylbenzene; (H) cyclohexane; (I) benzene; and (J) carbon tetrachloride

**Table 1. Characteristic frequencies of linkages**

Bond	Frequency	Bond	Frequency	Bond	Frequency
C — C	800-860 $\text{cm}^{-1}$	C — O	820-880 $\text{cm}^{-1}$	C — N	880-930 $\text{cm}^{-1}$
C = C	1600-1650 $\text{cm}^{-1}$	C = O	1710-1750 $\text{cm}^{-1}$	C = N	1650 $\text{cm}^{-1}$
C $\equiv$ C	2100-2250 $\text{cm}^{-1}$	—	—	C $\equiv$ N	2150 $\text{cm}^{-1}$

to associate a characteristic frequency with a particular type of linkage. It must be emphasized that this is only an approximation but one which has proved useful. The actual frequencies depend to some extent on the remainder of the molecule and so are only approximate.

Single bonds involving carbon, nitrogen and oxygen have characteristic frequencies of about 800  $\text{cm}^{-1}$ , double bonds about 1600  $\text{cm}^{-1}$  and triple bonds approximately 2100  $\text{cm}^{-1}$ . If hydrogen is attached to one of these atoms, e.g., C—H, the frequency increases to about 3000  $\text{cm}^{-1}$ . If a heavy atom is linked to carbon, the characteristic frequency decreases significantly: 650  $\text{cm}^{-1}$  to 710  $\text{cm}^{-1}$  for C—Cl.

So Raman spectrum is a valuable tool in the study of molecular structure. In fact, a final verdict about the much debated structure of benzene was given by Ingold School (C. Ingold, England, 1953) after using Raman spectra. This application is particularly useful in the analysis of complex mixtures of aromatic, olefinic, paraffinic and cycloparaffinic hydrocarbons, mineral oils and various isomers. The study of isomers is of industrial significance since the petroleum industry deals

with it. Detection and estimation of saturated and unsaturated hydrocarbon halogen derivatives, alcohols, ethers, aldehydes, ketones, heterocyclic and homocyclic compounds is possible from the study of Raman spectra.

Raman effect is useful in crystal study also. It furnishes information about different kinds of crystal formation dealing more with dynamical behaviour; strength and nature of forces that hold the atoms together in a crystal; frequencies with which they oscillate when disturbed from equilibrium positions, etc.

Much light has been thrown by Raman effect on nuclear chemistry. It gives information about spin of the nuclei of various atoms. From Raman spectra it has been found that nitrogen nuclei follow Bose-Einstein statistics. This, in other words, proves that electrons cannot be present in the nucleus. This is a conclusive piece of evidence to show that the atomic nucleus consists of protons and neutrons and not electrons.

The idea of resonance—both electron exchange hybridisation and the bond-multiplicity hybridisation—has been substantiated by Raman spectra studies.

Though the Raman effect is a property owned by physics, it seems to find more applications in chemistry. The U.S. physicist J.H. Hibben observes that "Raman effect began as the stepchild of physics but as time progressed it became the adopted child of chemistry". Today, Raman effect has applications not only in the fields of physics and chemistry but many other scientific disciplines.

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MANY of the pharmaceutical products available in the market comprise either natural products derived from terrestrial microorganisms, plants and animals or their synthetic analogues. The diminishing source of terrestrial life forms as well as the resistance developed

as a source of various minerals. As early as eighth century B.C., the Chinese and Japanese used seaweeds and other algae to treat intestinal disorders. Seaweeds have also been used for treating conditions like dropsy, menstrual difficulties, gastro-intestinal disorders,

also a good source of thiamin, niacin, riboflavin, folic acid, tocopherol, vitamin-A, ascorbic acid and ergosterol. Compounds isolated from them so far have been found to possess antibacterial properties; they include fatty acids of varying molecular weight, derivatives of certain terpenes

## PHARMACEUTICALS FROM

# ALGAE

by pathogenic organisms to many conventional antibiotics, have placed many constraints upon the pharmaceutical industry in the development of new products. In their search for new and more effective chemicals scientists are trying to evolve substances of therapeutic importance from the vast and diverse range of oceanic life forms. Among them are marine algae, a diverse group of autotrophic organisms.

Marine and fresh-water algae have long been used by man, chiefly for cattle feed, manure and

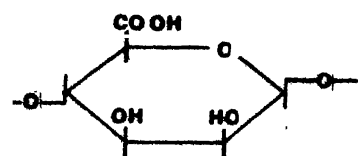
abscesses and even cancer. However, the search for drugs from marine algae is a relatively recent undertaking.

The phytoplankton and the macroalgae, the primary producers in the marine environment, produce substances which have a broad spectrum of antibiotic activity. Among the red, brown and green algae, the diatoms and dinoflagellates, there are many members possessing a wide variety of pharmacological activity. Certain genera in these groups of algae contain useful phycocolloids. They are

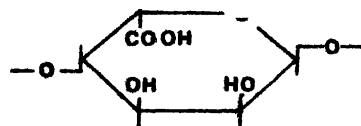
and of chlorophyll, brominated phenolic compounds, acrylic acid and certain polysaccharide sulphates. This article discusses the biochemical and pharmaceutical aspects of some of these substances.

### Alginates

Alginates, an important extract from brown algae, are the salts of alginic acid with sodium, potassium, ammonium, calcium and propylene-glycol. The acid is a long chain of uronic acid (D-mannuronic and L-



**D-MANNURONIC ACID**



**L-GLUCORONIC ACID**

**Fig. 1. Uronic acid**

glucuronic) group joined by 1,4 glycoside linkages (Fig 1). The brown algae commonly used for algin extraction belong to the genera *Fucus*, *Macrocystis*, *Laminaria*, *Alaria*, *Ecklonia*, *Eusemia*, *Durvillea*, *Cytoseira* and *Lessonia* (Fig. 2). Alginates find wide use in pharmaceuticals. They are used as tablet disintegrating agents; 3% - 10% alginic acid in tablets disintegrates them much faster than those containing 15% starch. They are also used as blood anticoagulants; an absorbable haemostatic material for control of surface bleeding; in the preparation of sustained release formulations and in formulations for dental impression materials. Alginates may also be used for the prevention and treatment of radioactive strontium poisoning. The alginates with higher concentrations of glucuronic acid have a greater affinity for divalent cations and have higher selective binding capacity for strontium than calcium. They form gells with radioactive strontium in the gastrointestinal tract thereby preventing its absorption in the body.

**Fig. 2. Brown algae; (1) *Laminaria*, (2) *Macrocystis* (3) *Fucus* (4) *Ascophyllum* (5) *Alaria***

The brown macroalgae are commonly known as 'Kelp', but originally the term referred to the ash rich in soda and potash, obtained by burning marine plants. Different species of the genera *Laminaria*, *Fucus*, *Saccorhiza*, *Ascophyllum*, *Ecklonia* and *Eusemia* are now employed for kelp production. The kelp extract contains a number of chemical elements, notably potassium and iodine. As iodine is an important constituent of thyroid hormones, kelp extract is useful in the chemotherapy of thyroids. It is used for the treatment of goitre as well.

*Laminaria coloustani* and other related members yield the polysaccharide, laminarin, comprising D-glucose residues joined mainly through 1-3-type linkages (Fig. 3). The highly sulphated derivatives of the polysaccharide have anticoagulant properties while the less sulphated groups have antilipemic (fat reducing) properties without anticoagulant activity. The latter property permits its use as an effective antilipemic agent without the hazards of concomitant anticoagulant action.

Investigations based on folk medicine have lead to the isolation of laminine dioxalate (5-amino-5-carboxy





and *Ecklonia cava*.

Recently anticancer properties of non-dialyzable fractions from *Sargassum fulvellum* and *S. thumbergi* have been reported against 'sarcoma 180' tumor system, and 'Ehrlich ascites carcinoma' respectively.



**Agar-agar**, a complex polysaccharide, is the most important product of red algae. It finds wide use in microbiological studies and pharmaceutical industry. Agar is extracted mainly from different species of *Gelidium*, *Hypnea*, *Gracillaria*, *Gigartine*, *Ceramium*, *Pterocladia*, *Suhria*, *Ahnfeltia* and other genera which produce and store it along with cellulose in their cell walls (Fig. 4). Studies with *Gelidium* sp. have shown the active component of agar to be a linear polysaccharide of 9- $\beta$ -D-galactopyranose, linked in 1-4' bonds with sulphated L-galactose (Fig. 5). Agar is extensively used in medicine chiefly as laxative; sometimes it is prescribed for treating a prolapsed rectum and is also employed as a dietetic. When used as a substrate for certain types of virus infected tissues (EMC or encephalomyocarditis virus), agar inhibits the development of the virus.

Another principal product from red algae is carrageenan. Chemically similar to agar, it is also a linear polysaccharide consisting of D-galactose-3-6-anhydro-D-galactose as the basic unit. It is composed of two fractions, the branched *kappa* and unbranched *lambda* carrageenan (Fig. 6). The major source of carrageenan is *Chondrus crispus* and some species of *Gigartina* and *Eucheuma*. Besides its use as a remedy for cough, carrageenan has recently been found beneficial for its anti-peptic and anti-ulcer properties and also as a potent anticoagulant and antithrombic substance.

The reported antiviral properties of both the above polysaccharides have been attributed to their galactan units; other similar polysaccharides which lack such units have no such activity. Specific antiviral activity

**Fig. 4. Red algae; (1) *Gigartina*, (2) *Gracilaria* (3) *Ahsefelia* (4) *Elidium*, (5) *Chondrus***

has been demonstrated against influenza B and mumps virus in embryonated chicken eggs.

It has been reported that intravenous injections of carrageenan from *Chondrus crispus* and laminarin sulphate from *Laminaria digitata* significantly reduce serum lipids and prevent the development of atherosclerosis. More recent reports show that algal polysaccharides or dried algae when orally administered reduce serum cholesterol in rats. In rats, carrageenan treatment has been shown to increase uptake of calcium in bone and to reduce serum calcium. This may be of potential benefit to persons suffering from osteoporosis or similar disorders. Overdose of barium, cadmium and zinc have also been effectively treated in rats by administering algal polysaccharides.

Apart from these products which offer great possibilities for commercial exploitation, there are some important but less economic algae or algal products which are used for curing various ailments. For example, kainic acid (2-carboxy-3-carbonylmethyl-4-pyrrolidine) isolated from the red alga *Digenia simplex* is widely used in Japan for its vermifuge and antihelminthic properties against the parasitic round worm, *Ascaris limbricoides*, the whip worm, *Trichuris trichura* and the tape worm *Taenia* spp. Kainic acid is available both in powder and tablet forms. In combination with piperazine adipate it is used in the treatment of ascariasis, trichuriasis and oxyuriasis. Currently, domoic acid [2-carboxy-4 (1-methyl-5-carboxy-trans-5-trans-1, 3-hexa dienyl)-3-pyrrolidin acetic acid] obtained from *Chondria armata* is being investigated for its antagonistic effects on *Oxyuris* as well as *Ascaris* worms.

Many algae are known to produce antibacterial substances effective

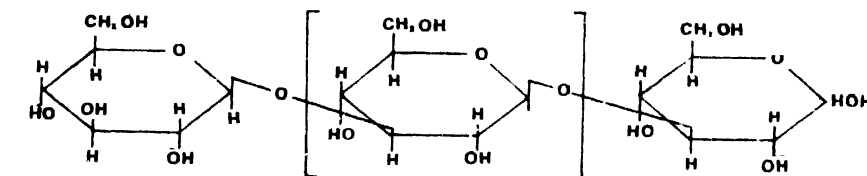
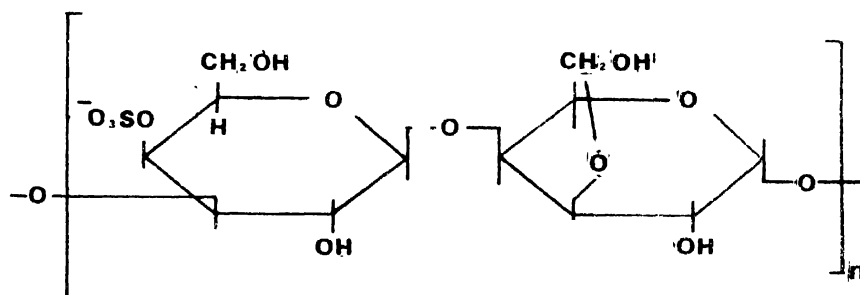


Fig. 5. Galactopyranose

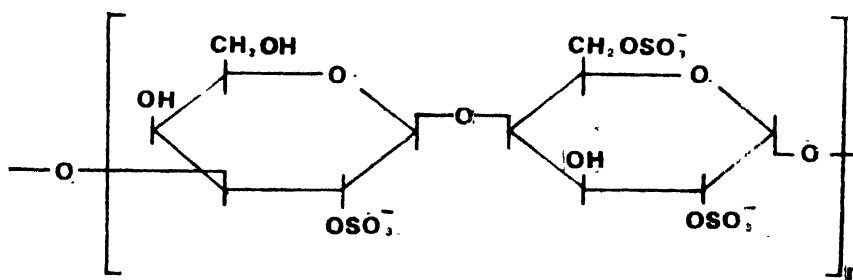
tive against a number of pathogenic bacteria. Chlorellein produced by *Chlorella* was the first kind of such substances. The extra-cellular products released in nature by certain algae such as *Sargassum* are found to be active against bacteria. Extracts from *Cladophora* and other algae have been reported to kill strains of *Pseudomonas* and *Mycobacterium* and also exhibit antiviral activity. Organisms such as *Dasya*, *Halimeda* and *Macrocystis* are reported to release antibiotic substances under laboratory conditions. I. S. Harnsey and D. Hide, Department of Applied

Biology, North Eastern London Polytechnic, London, after studying several dozens of British marine algae concluded that about one third appeared to possess antibacterial activity which vary with age and different parts of the thallus.

Some of the marine and freshwater genera of Cyanophyta also possess interesting pharmacological activity. The alga *Lyngbya majuscula* has been implicated in the outbreaks of dermatitis among swimmers and toxicity in fish and mice, but it also shows antimicrobial, antiviral, fun-



K-CARRAGEENAN



λ-CARRAGEENAN

Fig. 6

gicidal and other type of growth inhibitory properties. An anticancer compound, Debroaplysia toxin, has been isolated from the *Lyngbya gracilis* population of Marshall Islands in Pacific. Chloroform extracts of *L. gracilis* and other related members of the same family show antagonistic effect against a lymphocytic mouse leukemia.

There are many algae which have different pharmacological activities. They are usually members of Bacillariophyta, Pyrrophyta and certain genera of green algae. Many of them produce and release extracellular substances which are very toxic in nature. Significantly some of the marine toxins are considered to be among the most poisonous substances known. After dilution, such toxins may be utilized as useful therapeutic agents.

Among the major countries actively engaged in the production of potential algal pharmaceutical products are the United States, Britain, Canada, Japan, New Zealand, Austria, some countries in Africa, South America and Europe. In India, some preliminary studies have been undertaken by Central Salt and Marine Chemical Research Institute, Bhavanagar. After screening several marine algae for antiviral, antibacterial and fungicidal activity, P.S. Rao and others have tested the antibiotic substance isolated from *Enteromorpha* against clinical isolates of *Mycobacterium tuberculosis*. They could get complete inhibition of the tubercle bacilli in culture. These workers

have also found that such antibacterial activity exists in different fractions (pigments, phenol, as well as fraction A and fraction B of the lipid) of seaweeds such as *Enteromorpha intestinalis*, *Caulerpa taxifolia*, *Padina gymnospora*, *Gelidiella acerosa* and *Gracilaria corticata*. At the Marine Algal Research Station of CSMCRI at Mandapam (Tamil Nadu) K. Subharamaiah and coworkers are engaged in cultivation and harvesting of the agar-producing and other pharmaceutically important marine algae.

The main task here is the collection of marine organisms that manufacture biologically active substances, their separation and purification and study of their possible application in the treatment of diseases. One recent approach is to search for the existence of specific steroid molecules. Among algae, the green and red algae contain steroids usually found in land plants whereas brown algae have some unique compounds. Much attention has also been given to identification of the fatty acid constituents of marine algae because, as a byproduct of marine algal industry, the fatty acids may provide an inexpensive dietary component not only for man but for animals as well.

There are many problems that come in the way of the successful development of algal pharmaceuticals. Among them are lack of trained personnel, difficulties in culturing marine organisms, problems in the screening of crude extracts for biological activity, and difficulties

inherent in the extraction of natural products, their separation and characterization, etc. Some of these difficulties can be overcome by successful pooling of ideas, talent and experience of several related overlapping disciplines, viz., ecology, taxonomy, ethnobotany, pharmaceutical chemistry, pharmacognosy, pathology, oceanography, etc., and concentrating attention on problems which are most likely to yield new useful and marketable pharmaceuticals.

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able communications, specially for remote health care, the technical specifications of the equipment become an important factor. For instance, when telephone is used for other than transmission of relatively ambiguous data, its effectiveness is heavily dependent upon the credibility of the verbal description of the medical problem given to the doctor. The reliability

of communication system used for remote health care is essential if one expects the user to fully depend upon it.

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## What is at the centre of Milky Way?

**I**N recent years astronomers have paid considerable attention to the centre of our galaxy *Milky Way*. Reasons are many but two would suffice here. It has been found that a lot of matter and energy is periodically released from the centres of some nearby galaxies. Studying our galactic centre or nucleus, which is about 70 times closer to us than any other galactic nuclei, will help in understanding not only the mechanisms responsible for the release of matter and energy but also the evolution of galaxies. It is also being increasingly felt that a black hole, that elusive heavenly object, supermassive and intriguing in all aspects, is present at our galactic centre. Studying the galactic centre would mean studying the various characteristics of a black hole which are of fundamental importance. Besides the centre is also as good as an astronomical zoo. It contains almost all astronomical objects hitherto discovered, namely, various types of stars, gaseous nebula, neutron stars, etc.

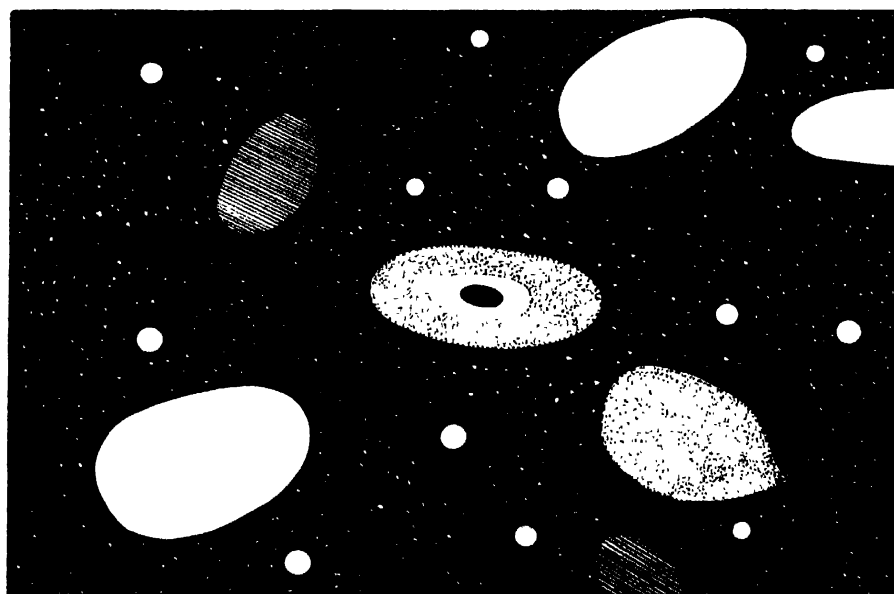
Until 1930s nothing was known about the galactic centre because it is behind a curtain of dust clouds. It was only after Karl Jansky listened in on to some radio hiss com-

ing straight from the galactic centre that researches began in that direction. Study of the galactic centre was made over a wide range of radio waves, but many gaps in the knowledge remained unplugged as research continued, and the need for a new tool for exploring it further was increasingly felt. In the 60s and 70s, infrared astronomy began to assume importance, and

in no time infrared rays coming from the galactic centre came under scrutiny. Today, the need for more powerful infrared telescopes is still felt as the centre reveals many interesting aspects which need further detailed observations. However, to a large extent the picture of the centre of the galaxy is clear.

Instead of considering the galactic centre vaguely without any assigned boundary, consider only its central parsec. A parsec is an astronomical unit of measuring length. In the night sky, the central parsec of the galaxy is of the size of a medium-sized crater of moon. Otherwise, it is about 3.26 lightyears (one lightyear =  $9.46 \times 10^{15}$  meter) in diameter, which is about the distance between sun and the nearest star. It is in the Sagittarius constellation. The central parsec contains at its centre a strong radio source, called Sagittarius A, which has further been found to contain a group of sources, of which Sagittarius A West is the most powerful.

By studying the central parsec at various radio and infrared wavelengths, various discoveries have been



A diagrammatic view of the centre of our galaxy *Milky Way*, about three parsecs across. In the centre is the postulated black hole; varied patches are of interstellar gas and dust; big round spots are red giants, and in the background are the stars



made. It has been found that it contains about 2 million stars, clouds of ionised gases, red giant stars, besides cold interstellar dust. In other words, the varied radiation coming from the central parsec is not of one source but many, some strong and thus recognisable, and others weak and undetectable. It has been found that the ionised gases are in rapid motion, whether turbulent or organised is not known. However, on the whole the gases rotate about an axis, which is surprisingly perpendicular to that of the rotation of the main galactic disk (*Scientific American* July 79). It is believed that this overall rotation must also be of other objects present in the central parsec. Speed of rotation is quite high, about 10,000 years per round about the centre of the galaxy as compared to sun's 200 million years.

From the rotation rate of the central parsec and other considerations, mass of the central parsec has been estimated. So also masses of stars of all types and dust and gases present in the parsec have been estimated. It has been found that of the total 5 to 8 million solar masses (one sun's masses) of the central parsec, stars amount to 2 million solar masses and dust only about 10 solar masses. Question that faces astronomers is: what has happened to the remaining 3 to 6 million solar masses of the central parsec? Is it the proverbial missing matter in the galaxy or an error in calculations?

All things considered, astronomers have now begun to feel that the huge mass is of nothing else but a black hole embedded at the centre of the galaxy. For instance, the low ionisation state in which the gases are found in the central parsecs can only be accounted for by a radiating black hole. Also, velocities of gases tend to increase toward the centre in the central parsec, which is also not possible without the existence

of a highly dense core, such as that of a black hole at the centre. A black hole would swallow incoming material, such as stellar winds, planetary nebulas, and debris of colliding stars, from the surroundings and store it in form of a rotating disk about itself.

The evidence for the presence of the black hole is not yet conclusive,

and the contemporary astronomers are working in this direction. They are eagerly awaiting the completion of the Very Large Array Radio facility near Socorro, U.S.A., which would throw more light on the central parsec through its more powerful eyes.

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## Fuel cells—the novel power generators

**M**OST of the electrical energy used today is generated by alternators at steam turbines. The steam is produced by burning fossil fuels (coal or hydrocarbons), or by nuclear fission. The chemical energy of a reaction of interaction of an oxidizer (the oxygen of the air) and a reducer (fuel) is also utilised for the production of electrical energy at heat power plants. In all these cases, however, the conversion of energy follows a complicated path, the chemical energy is first of all transformed into heat, then into mechanical energy and only then into electrical energy. The maximum electrical work attained in such a conversion is determined by the heat of reaction ( $Q_p = \Delta H$ ).

$$W' = Q_p \frac{T_1}{T_2}$$

Efficiency losses also take place at every stage. The Carnot cycle shows that the thermal efficiency of any heat engine is limited to  $E$ , where

$$E = \frac{T_2 - T_1}{T_2}$$

$T_2$  and  $T_1$  being the temperatures in degrees kelvin, at which heat is supplied to, and rejected by, the system. In practice, upper temperatures

are limited to about 500°C (773K), lower temperatures are at least 30°C (303K) and efficiencies are limited to a maximum of 60 per cent. Indeed most modern, large power stations are able to achieve only 38 per cent to 40 per cent efficiency. For this reason scientists have been trying to create devices for the direct conversion of chemical into electrical energy.

This requires the development of galvanic cells, in which the reactions of oxidation of the fuel and reduction of oxygen proceed electrochemically. The initial attempts to fabricate such fuel cells were not successful owing to the very low rate of the reaction of electrochemical oxidation of the usual kinds of fuel. Only in the last few years, as a result of employment of various catalysts and improving the design of the cells did scientists succeed in creating the first satisfactorily functioning laboratory model of the fuel cells using gaseous fuel.

Fuel cells convert fuel directly into electrical energy by an electrochemical route which is not limited by the Carnot cycle. Cells being developed range from 1 Kilowatt to 2 Kilowatts to several megawatts, because their efficiency is not related to size. In contrast to batteries, the cells generate power rather than store it, and continue to do so as long

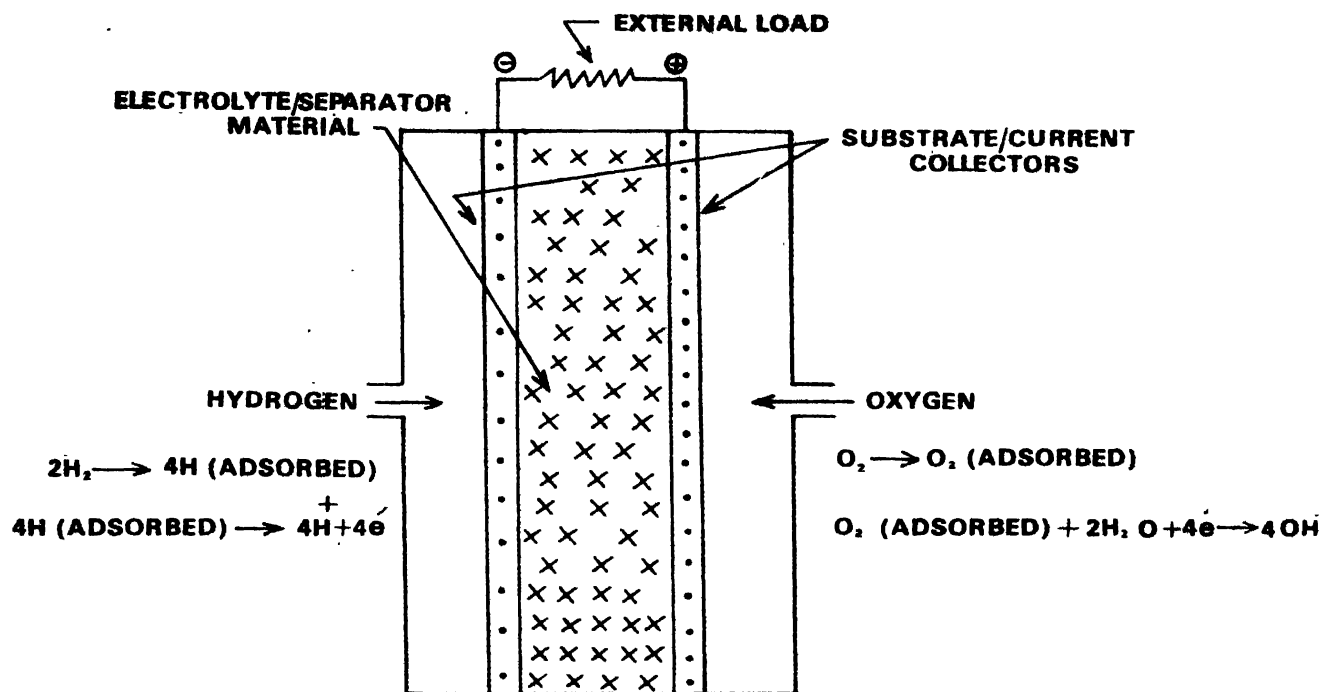


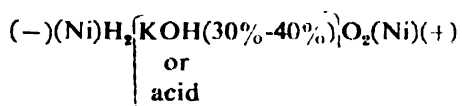
Fig. 1. Simple fuel cells

as a fuel supply is maintained; there is no recharging cycle. The high thermal efficiency and low environmental pollution characteristics of this novel power source are likely to increase its generating capacity for both peak and intermediate applications.

The simplest fuel cells run on hydrogen and oxygen; their operation is the converse of the electrolysis of water. This effect was discovered in 1839 by Sir William Grove, who found that electrolysis between platinum electrodes could be reversed, with the consequent generation of electric current and production of water.

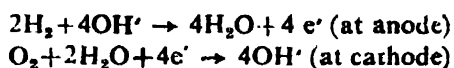
The simple unit cell consists of two electrodes, one of which is supplied with hydrogen (the anode) and the other with oxygen (the cathode). These electrodes are made electrically conducting and porous so that gases can diffuse through them. Between the electrode pair is an electrolyte, usually a strong acid or alkali. The purpose of this is to prevent mixing of the molecular gases fed to the

electrodes, while permitting charged chemical species (ions) to pass from one electrode to the other carrying an electrical current. Connecting an external load across the electrodes completes a circuit, the passage of electrons through the load resistance constituting the work done by the cell. Such a cell can be symbolized as follows

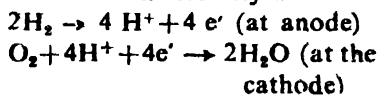


During operation of the cell, the following electrode reactions proceed :

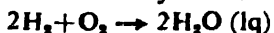
For alkali electrolyte :



For an acid electrolyte



The summary reaction is



Current is carried through the electrolyte between the electrodes by the positively charged protons ( $\text{H}^+$ ) or hydroxyl ions ( $\text{OH}^-$ ) and round the external load by the electrons ( $\text{e}^-$ ).

Considering the thermodynamics of the system for a cell with no current flowing, that is, at reversible equilibrium, it may be shown that the standard free energy change ( $\Delta G^\circ$ ) is related to the standard electromotive force ( $E^\circ$ ) by the relationship :

$$\Delta G^\circ = -nFE^\circ$$

where  $n$  is the number of electrons involved, and  $F$  is the Faraday constant of 96,500 coulombs per equivalent. The standard free energy for the chemical reaction forming water is  $-113.38 \text{ K cal mol. of oxygen consumed}$ ,  $n=4$  and 1 calorie is 4.18 joules. Hence, for the hydrogen-oxygen fuel cell the standard thermodynamic reversible potential at  $25^\circ\text{C}$  is 1.229 volts and it is independent of the composition of the electrolyte solution.

During the discharge of a hydrogen-oxygen cell, the voltage is within 0.7V-0.9V depending upon the density of the discharge current on the electrodes (in the best designs of cells the current density reaches 200-300mA/cm<sup>2</sup>).

In practice, the reversible potential is rarely attained due to the presence of trace impurities and side reactions such as peroxide formation mainly at the oxygen electrode.

### Practical fuel cells

Pairs of cells are connected in series forming stacks in order to get useful voltages. These are normally flat, packed back to back in a classical filter press configuration. For collecting current and uniform distribution of gas over the electrode surfaces, these may be supported by channelled backing plates. Reactant supplies are normally maintained higher than stoichiometric, that is, greater than is consumed in the reaction, the excess gases carry away heat, water and trace impurities.

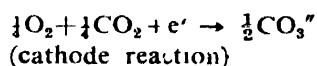
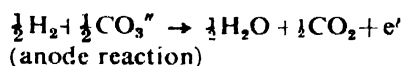
A compromise between heat removal, electrode activity and corrosion rate is usually achieved by operating the alkaline and acid cells between temperatures of 50°C and 250°C. To develop commercially viable power sources air is to be used as oxidant and anodes are to be tolerant of impure fuels, while still maintaining an adequate life time. Operation on air demands the use of acid electrolyte to avoid carbonation problems from atmospheric carbon dioxide. Phosphoric acid is used, despite its relatively low conductivity and highly corrosive properties, in preference to other acids which are mostly unstable in a fuel cell environment.

Alternative electrolytes under evaluation include halogenated sulphonic acids such as trifluoromethane sulphonic acid (TFMSA). Solid polymer electrolytes have also been widely used. Noble metal catalysts have

now been accepted as being the best choice, although other systems, such as tungsten carbide, have also been evaluated.

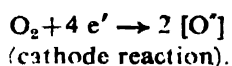
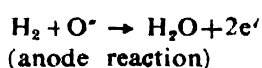
Fuel cells workable at high temperatures can be divided into those employing molten carbonate electrolytes and operate at about 600°C to 700°C, and solid electrolyte types operating at above 1000°C. Molten carbonate cells rely on high temperature to enhance reaction rates and thereby decrease electrode polarisation. Carbonate mixtures such as lithium and potassium are used, because other species such as hydroxides, chlorides, nitrates and sulphates do not give an acceptable combination of conductivity and stability in the molten state.

Most of the systems envisaged involve production of hydrogen from hydrocarbons or coal by an external reformer to yield hydrogen/carbon dioxide mixtures which are fed to the anode.



The combusted anode gas is then enriched with air and fed to cathode where it replaces the carbonate ion in the electrolyte.

Certain oxide materials exhibit solid state electrical conductivity at temperatures of about 1000°C. The most widely studied solid electrolytes are based on zirconia. This material is stable as the monoclinic form at room temperature and is transformed into the tetragonal form at 1150°C, accompanied by a 9 per cent volume contraction. The fuels generally used are hydrogen and oxygen, thus



In this case oxide ions [O<sup>2-</sup>] act as the current carrying species in the electrolyte. If the oxygen content becomes depleted during cell operation, the material may become a semiconductor, resulting in a loss of cell efficiency.

### Methanol cells

Methanol is the most promising fuel for low power terrestrial applications such as vehicle traction and portable generators. It is easily transportable and stored, and is available in bulk. It can be electrochemically oxidised to carbon dioxide and water; the thermodynamically reversible potential being 1.20 Volts.

Direct methanol cells, where the fuel is dissolved in the electrolyte, have improved mass transfer characteristics compared with gas diffusion electrode types. Unfortunately, methanol also diffuses to the cathode and is chemically oxidised, but this can be prevented if a semipermeable membrane is imposed between the anode and cathode.

The first fuel cell applications for motor vehicles are likely to be for methanol fuelled units for public utility transport.

At present the development of fuel cells is still in its initial stage.

In principle, the possibility of using certain kinds of fuel in such cells and the conversion of its chemical energy into electrical energy with a practical efficiency upto 75%-90% has been proved. Because of their low pollutant emissions and silent operation, these fuel cells could be located close to the centres of population, eliminating a high proportion of power transmission costs. That is why it has been predicted that in future electric power utilities will use nuclear or fossil fuel base load generators, running continuously at full load and optimum efficiency. These will be supplemented by fuel

cell generators capable of providing the bulk of intermediate and peak power requirements; thus utilising their ability to operate efficiently at part load.

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rous precipitate obtained is dried and ground to a powder.

### Structure

Scleroglucan is a neutral D-glucan (polysaccharide made up of D-glucose residues). It contains a linear chain of  $\beta$ -D-glucopyranosyl units joined through (1 $\rightarrow$ 3) glycosidic linkages in which every third glucose residue carries a branch of single  $\beta$ -D-glucopyranosyl residue at C<sub>6</sub>. The repeating unit of scleroglucan is shown in Fig. 1.

The polysaccharide has a degree of polymerisation (D) ranging from 110 to 1600 (molecular weight 17,000 to 2,59,000) depending upon the type of fungus used for its production. Scleroglucan used for commercial purposes has a DP of  $\sim$  800 (molecular weight 1,09,600).

### Physical properties

Scleroglucan disperses easily in water to give a highly viscous solution. The viscosity of aqueous solution is relatively independent of temperature over a wide range (between 10°C to 120°C) and of pH (1 to 10). It possesses a high degree of pseudoplasticity (decrease in viscosity as the shear rate increases) and has an excellent suspending ability. (Even

## Scleroglucan—a fungal polysaccharide

**S**CLEROGLUCAN is an extracellular fungal polysaccharide. It is secreted by the mycelia of some fungi, notably by species of the genus *Sclerotium* (e.g., *Sclerotium glaucum*). The physical properties of scleroglucan are comparable with that of industrially important bacterial polysaccharides and it thus serves as an important industrial gum. Its potential industrial importance as gum was first recognised in 1967; since then it has been rapidly commercialised.

### Production

Scleroglucan is produced by aerobic fermentation of D-glucose by a selected species of *Sclerotium* fungi. The fermentation is allowed to proceed at 30°C in a medium containing D-glucose, corn steep liquor, nitrate (as nitrogen source) and mineral salts. The initial pH of the fermentation medium is adjusted to 4.5. When fermentation is completed (requires about 60 hours), the pH drops to 2. The polysaccharide so produced is present as capsule round the mycelium and is largely immiscible with water.

The final fermentation liquor is heated to inactivate polysaccharide degrading enzyme and to kill the fungus which is a plant pathogen. Then the liquor is homogenised

to disintegrate the gum from the mycelium. For industrial applications that can tolerate residual mycelium, nutrients, and metabolites spray drying the homogenised fermentation liquor provide a satisfactory product. But for special purposes (i.e., use in food, drug and cosmetics) the product is refined by filtration and precipitated with alcohol.

The homogenised fermentation liquor is extremely viscous and is diluted before filtration. The diluted solution is filtered by applying pressure to remove mycelium and other particulate matter. The clear filtrate is concentrated and the polysaccharide is precipitated by the addition of 2-propanol or methanol. The fib-

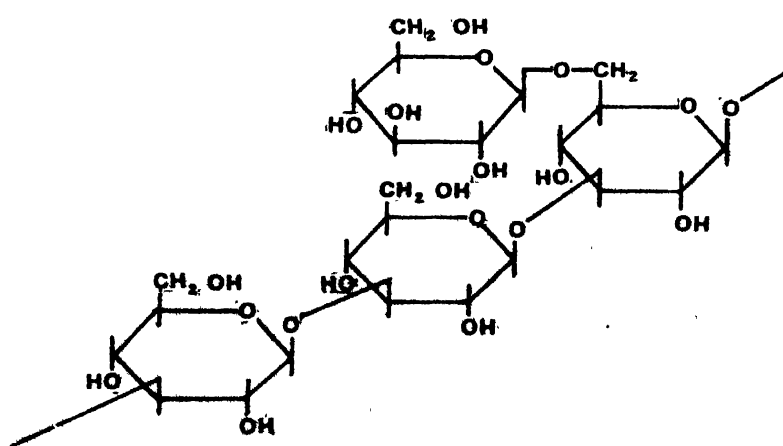


Fig. 1. Repeating unit of scleroglucan

in 0.1% to 0.2% concentrations it effectively stabilises 5% to 10% aqueous suspension of a fine powder). It is compatible with a wide variety of electrolytes (mono- and poly-valent cations and anions) in moderate to high concentrations. Aqueous solutions of the gum on evaporation gives strong films which when plasticised with glycerol remain tough and pliable indefinitely. Solutions and gels of the gum are tacitly distinctive---they are neither slimy nor sticky.

### Physiology

Scleroglucan undergoes metabolism in the body when fed to animals and possesses a caloric value equivalent to starch. Feeding studies with experimental animals have indicated that it causes no toxicity, adverse reactions, blood abnormalities or sensitisation. It reduces the level of cholesterol in the blood and increases excretion of lipids.

### Uses

Scleroglucan has a wide range of industrial and non-industrial uses. It is used in secondary oil recovery, drilling muds, paper-coatings, printing inks, porcelain and ceramic glazes, extruded refractory products, integrated circuit chips, insulators, pesticide and defoliant sprays, agriculture seed coatings, and as liquid animal feed concentrates, as a source of gentibiose (a disaccharide), and as a ceramic binder.

In pharmaceutical industry, scleroglucan is used in tablet coatings, ophthalmic solutions, injectable antibiotic suspensions, anti-acid suspensions and in calamine lotion. In cosmetic industry it is used in hair sprays, hand lotions and antisoilant skin coatings. In food industry, scleroglucan finds use as bodying, suspending and gelling agent.

A number of scleroglucan derivatives such as methyl, carboxymethyl,

benzyl, cyanomethyl ethers, and acetate, benzoate, sulphate esters have been prepared. The industrial applications of these products are still to be exploited.

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## Regulation of biological nitrogen fixation

**N**ITROGEN is an essential constituent of all living organisms. Unfortunately, nitrogen gas which forms 80% of our atmosphere is one of the inert gases and cannot be directly used by plants and animals. It has to be reduced to ammonia and subsequently converted into other compounds before it can be used by plants and animals. This reduction of nitrogen to ammonia is accomplished by few species of microorganisms which can produce enzyme 'nitrogenase'. This process is known as 'biological nitrogen fixation'.

This enzymatic reduction of nitrogen to ammonia essentially needs energy reducing power (electrons) and proceeds under anaerobic or reduced oxygen pressure conditions. The ammonia formed is further transaminated into intermediates of the TCA cycle to form amino acids which, in turn, are used for building protein units.

The different processes that are taking place in a bacterial cell must proceed in an orderly sequence and in a balanced way. All these processes are interrelated and precisely regulated through control mechanism. Since nitrogen fixation is one of these processes, it is also under a regulatory mechanism.

An operon (a set of genes called 'nif' genes, now termed as 'regulon' since genes are scattered) in the cell is responsible for synthesis of nitrogenase. This gene is transcribed first into a mRNA (messenger RNA)

by DNA dependent RNA polymerase. This mRNA is translated on ribosomes and results in production of nitrogenase. Nitrogenase enzyme has two sub-units, one an iron containing protein and the other iron and molybdenum containing protein. Separate mRNA's are produced for synthesis of each of the protein sub-units. After the synthesis they come together and active nitrogenase enzyme complex is formed. The triggering 'on' or 'off' of the 'nif' genes is regulated by various factors in the cell.

Ammonium, being an end product of nitrogen fixation, has to be used up immediately through transamination; otherwise, the accumulation of ammonium represses the nitrogenase synthesis and affects the nitrogenase activity too. This probably gave a hint to the researchers that the enzymes responsible for ammonium assimilation may be playing a role in regulating nitrogenase synthesis. Thus glutamine synthetase, an ammonium assimilating enzyme, has been suggested as a regulator for enzyme nitrogenase. The mutants of *Klebsiella pneumoniae* lacking glutamine synthetase did not exhibit nitrogenase activity. When these mutants were mated with *K. pneumoniae* strains, capable of synthesizing glutamine synthetase, the mutants regained the ability to synthesize glutamine synthetase. Simultaneously, the capacity to synthesize nitrogenase was also exhibited.

It is interesting to note that the

increasing amounts of nitrogen added to the medium repress the nitrogenase activity. It is logical to think that when nitrogen is already available why should the organisms fix it. The different metabolic processes in the biological system are highly regulated to conserve energy. The transcription and translation of nitrogenase and nitrogen fixation processes are energy consuming ones. Obviously they are prevented from happening when nitrogen is made available to the organisms.

Experiments further provide the evidence for the mode of action of nitrogen on nitrogenase synthesis activity. We have glutamate dehydrogenase which is also an enzyme of ammonium assimilation pathway. Glutamine synthetase performs assimilation of ammonium when ammonium concentration is very low and needs energy input (ATP) for its assimilation reaction. Glutamate dehydrogenase performs ammonium assimilation when ammonium concentration is high and does not need energy input (ATP) for its reaction. When we supply nitrogen, the nitrogen concentration in the cell goes up and the organisms prefer to assimilate the nitrogen by glutamate dehydrogenase pathway. Thus ATP which is needed for glutamine synthetase reaction is conserved. This occurs by the induction of enzyme glutamate dehydrogenase which upon synthesis represses the synthesis of glutamine synthetase. Since glutamine synthetase is needed for nitrogen fixation, it does not take place when glutamine synthetase is repressed. Whether glutamine synthetase is required for initiation of nitrogenase synthesis or for nitrogenase activity is still not clear. As per Stricher's hypothesis this may bind to the regulatory site of the *nif* gene and initiate the transcription of nitrogenase but the experimental evidence for the same is yet to be provided.

It is thus clear that the concentra-

tion of nitrogen is also important. Glutamate dehydrogenase is only synthesized when nitrogen concentration is high. Probably the minimum threshold concentration is not at all reached in nitrogen fixing organisms so that glutamate dehydrogenase induction does not take place at all. Since accumulation of ammoniacal nitrogen is very low, glutamine synthetase performs the assimilatory function. Whenever nitrogen concentration increases due to addition of nitrogenous compounds repression takes place. Thus the effect of nitrogen addition on nitrogen fixation may be possible through glutamine synthetase.

Suppose nitrogenase synthesis is shut off by adding mineral nitrogen, what will happen to the nitrogenase enzyme already synthesized and participating in nitrogen fixation?

Will it go on fixing nitrogen even in the presence of nitrogen? Experimental results provide the answers. When nitrogen is added, the nitrogenase already present in the cell undergoes denaturation similar to that of oxygen damage. Since nitrogenase is sensitive to oxygen, (nitrogen fixation is an anaerobic process) when exposed to oxygen it undergoes denaturation and loses the capacity to fix nitrogen. This denaturation of nitrogenase enzyme caused both by addition of nitrogen and by exposing to oxygen are alike. This has been confirmed by X-ray crystallographic studies.

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## Ginkgo—the living fossil

THE plant *Ginkgo biloba* has probably existed on earth longer than any other known tree that is now living. This is the only surviving species of a once widely distributed group of gymnospermous plants, now found mostly as fossils. It is the only representative of the group of plants that fossil remains show extended back 200 million years into the Triassic or even Permian periods, when great dinosaurs roamed the earth. Darwin called it a "Living fossil"; it has persisted on this earth for about 150 million years without experiencing any evolutionary changes, keeping a link with its extinct ancestors of millions of years ago. *Ginkgo biloba*, is the only living member of the order Ginkgoales, family *Ginkgoaceae* and the genus *Ginkgo*. Fossil records indicate that there may have at one time been about

50 species of this genus. Some of them are known to have existed in other parts of the world including Australia, England, Japan and America.

Ginkgo still retains the 'swimming' male gametes bearing fine threads called cilia characteristic of primitive plants like ferns, and which probably characterized all of the Paleozoic (200-500 million years ago) seed plants. (In modern day flowering plants, the male gametes are passive and without cilia.) Its wood shows a type of tissue that has probably existed since the Devonian (300 million years ago) period.

The plant was first studied in Japan in 1690 by a European who proposed the generic name *Ginkgo*. The word was derived from the name of a favourite food in China, made of the enveloping pulp of the fruit.



Fig. 1. Two *Ginkgo biloba* trees during winter

called *pai-kuo* or *yin-kuo* (whence the name *Ginkgo*). However, the earliest mention in Chinese literature was in the eighth century A. D.

#### Evolution and distribution

The group of trees to which *Ginkgo biloba* belongs evolved from ancient seed ferns during Permian times (200 million years ago). Apparently, trees of this genus have existed since the late Triassic or earliest Jurassic period (180 million years ago). During the Tertiary (50 million years ago) and Quaternary (1 million years ago) periods, there were great upheavals on the earth followed by an ice age, which destroyed the *Ginkgo* trees and other *Ginkgoales* in most parts of the world. The destruction was least in East Asian countries like China, Japan and Korea, and probably all of the *Ginkgo* trees known today came from this part of the world. It is doubtful whether a natural

stand of *Ginkgo* trees can be found anywhere in the world today. The last native home of *Ginkgo* was probably China. Some botanists believe, there is evidence of its continued existence in South-eastern China since the Permian.

Religious people in China cultivated this tree in temples and monastery; it is because of this practice that we still have the plant surviving today. Besides China, it is now cultivated as an ornamental in Japan, United States and Europe. In India it was introduced possibly in the beginning of the present century, and there are several *Ginkgo* plants in a few gardens. The municipal garden at Mussoorie has two male trees; Forest Research Institute, Dehra Dun has six; Harbanswala, Dehra Dun, three (one of them produces fruits); the Government House, Nainital one female tree; the Botanic Garden, Darjeeling, one; and the Ootacamund Botanical Garden, a few trees. At the Company Bagh, Amritsar there were two female trees, but they were reportedly destroyed by natural calamities. The tree does not thrive in the plains of India, but does well on hills at an elevation of 1500 m. So far trees grown in India have failed to attain their normal size and have seldom produced fruits.

#### Main features of the plant

*Ginkgo biloba* is a deciduous tree; young leaves appear each spring (Figs. 1 and 2). The tree can reach 30m or more in height, bearing graceful branches and broad leaves. Young trees are usually cone-shaped (Fig. 3), but older ones become more rounded. The leaves are quite distinctive. They possess a relatively long petiole and an extremely flattened wedge-shaped blade. The blade is usually notched in the centre forming two roughly equal lobes, hence the species name *biloba*. The leaves have characteristic parallel

venation and resemble the leaves of the maidenhair fern (*Adiantum* spp.). For this reason the tree is also called "maidenhair tree." The plant can be either male or female; the former bears naked male flowers in catkin-like inflorescence and the latter naked female flowers (ovules), which are usually two in number (Fig. 4). The fruit is drupe-like and foul smelling. The plant is usually propagated by cuttings. Treatment with plant hormones like auxin helps in rooting.

#### Relevance to man

*Ginkgo* is famous simply for its graceful ornamental form. There are several cultivated varieties, e.g., *variegata* of yellow streaked leaves, *pendula* of the weeping form, etc. The dwarfs are widely raised in China. The Japanese once believed that it exudes water during fire.



Fig. 2. The same trees during spring

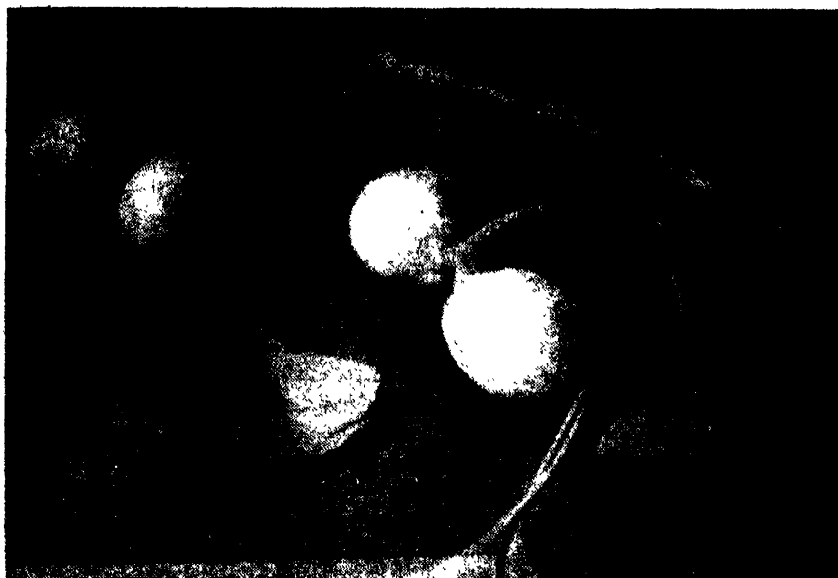


Fig. 3. A female shoot of *Ginkgo biloba* with mature ovules. (Photo courtesy: K. M. Vaid)

This belief was suggested by the fact that *Ginkgo* is more resistant to fire than many other trees. It can withstand atmospheric pollution, and many cities of the world are now using the species in parks and roadsides. City planners have succeeded in brightening New York City, Washington and other cities where millions of people live and work with this handsome tree. In our large cities like Calcutta, Bombay, Madras and New Delhi, *Ginkgo biloba* would be very helpful in checking air pollution as well as in beautifying the streets, if it is planted in large numbers. Horticulturists have recently voted it to be one of the eleven most beautiful trees in the world. While cities abroad are planting it in plenty we count them in fingers. For planting on roadsides male trees are preferred, because the females emit bad smell at the time of fruiting. The tree is almost free of insects and pests, it grows to large size and produces a valuable evengrained wood, which is used in China and Japan for making chessboards and toys. The wood also burns well as a fuel. These

facts suggest that it could become a valuable forest tree. However, for a number of reasons, it has not yet been tested in forestry.

*Ginkgo* seeds contain kernels which are eaten in China, particularly at wedding. It contains sucrose, starch, protein, fat, fibre and a sterol. The globulin of the kernel, accounting for 60 per cent of the total nitrogen, is rich in amino acid tryptophan. If eaten raw, seeds are mildly poisonous and may cause a skin rash. The seeds are also reported to be used in China for washing cloth; a detergent cosmetic is prepared by digesting the seeds in wine or oil.

One may wonder why the *Ginkgo* has remained unchanged over so many millions of years. Of course, it must have been eminently suited to the environment in which it found itself, for otherwise it would have died out or would have changed.

We know that evolution occurs largely through mutation (i.e., heritable changes) in the genetic material DNA. These changes can occur by physical or chemical agents. X-rays are particularly effective in produ-

cing mutations of genes. Natural radiation from cosmic rays and from radioactive substances in the soil produce mutations. It was previously thought that the chromosomes and genes of *Ginkgo biloba* might be resistant to mutation by radiations. But this is not true. A. H. Sparrow of the Brookhaven National Laboratory, U.S.A., has found that this plant is as sensitive to radiation as are other gymnospermous plants. But while both radiation and chemical mutagens are undoubtedly capable of causing mutations of the genes of *Ginkgo biloba*, the importance of these changes is kept to a minimum by the rather long time gap from one generation to the next. *Ginkgo* does not begin to reproduce until it is more than 20 years old, but it continues to reproduce upto age of over 1000 years. As a result, it has very much less chance of changing its characteristics than other plants, for most plants have a shorter reproductive period.

*Ginkgo* is reputed to be completely resistant to all serious pests and insect diseases and to have a high tolerance to city smoke and industrial fumes. It can grow well under a variety of situations. It has been shown to be resistant to fire also. The inheritance that provides *Ginkgo* with fire resistance has apparently provided it with the ability to resist the environmental pressures that would have through the centuries made it extinct. The plant has also been found to be resistant to certain viral, bacterial and fungal diseases. So it seems that all these factors which contribute to such resistance and tolerance might be at least part of the explanation for such a high longevity of *Ginkgo*.

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## Ultrasonic pregnancy detection in the small domestic animals

**I**N small domestic animals, it is hard to diagnose pregnancy. Their reproductive system cannot be examined easily. With the success of ultrasonic devices in detection of pregnancy in woman, similar instruments have also been developed for use in small domestic animals. Such instruments are gaining popularity, particularly, among pig farmers in western countries. Accuracy to the extent of 95 per cent has been achieved in detecting pregnancy in gilts and sows with 30 days pregnancy and more by the use of ultrasonic devices.

### Principle of ultrasonic detectors

An ultrasonic pregnancy detector generates a narrow beam of high frequency sound which, on coming in contact with the body, is reflected by various muscle layers and organs filled with fluid. The sound wave reflections, known as echoes, are displayed on a television-like screen in the instrument as vertical lines or spikes. The screen is divided into three zones, namely, left, middle and right zones. The distance from the probe to the object (the organ) reflecting the high frequency sound is proportional to the position of the spike in the screen. The ultrasonic pregnancy detector diagnoses pregnancy by detecting fluid in the uterus.

### Instruments

The types of instrument are at present available in the market. One type which is shock-free, light weight (2.8 kg) and handy (21×25×8 cm) detects pregnancy at a very

early stage (Fig. 1). The instrument possesses an on-off switch, indicator lamp, tone switch, sensitivity control, function selector and a probe connector socket. The instrument requires 30 seconds to 'warm up' when the indicator lamp and the television-like screen glow up, suggesting that the instrument is ready for use. The function selector switch is set for the desired function, i.e., for backfat thickness, sow pregnancy detection, cow/mare pregnancy detection or loin thickness. The sensitivity control switch helps adjust signal for best reading and sell from minimum to maximum sensitivity, with nine gradations. The abrasion resistant display window on the instrument is equipped with a scale for measuring backfat and loin thickness. The tone switch functions for auditory signals whenever desired. An audible signal is heard when an echo of at

least 1.8 cm occurs in the right zone of the screen. The detector probe is detachable from the probe connector socket. This is a battery operated instrument and the battery has a normal life of 1000 complete discharge cycles. Recharging of the battery requires 16 hours for full charge. When fully charged the unit operates for about 11 hours. One unit approximately costs Rs. 13,000/-.

The second type of instrument is a low cost ultrasonic pregnancy detector for swine and sheep (Fig. 2). It is made of heavy gauge aluminium and weighs about 0.45 kg and measures 4.5×6×15 cm. It is battery operated and supplies power enough for whole day operation on full charging. This is equipped with a probe and delivers auditory signal only. It costs about Rs. 4000/-.

### Operation of the instrument

Switch the instrument on. When the indicator lamp glows, wait until the screen displays light with divided baseline in three zones and a vertical line along the left hand side. Set the function selector switch for the purpose and adjust the sensitivity

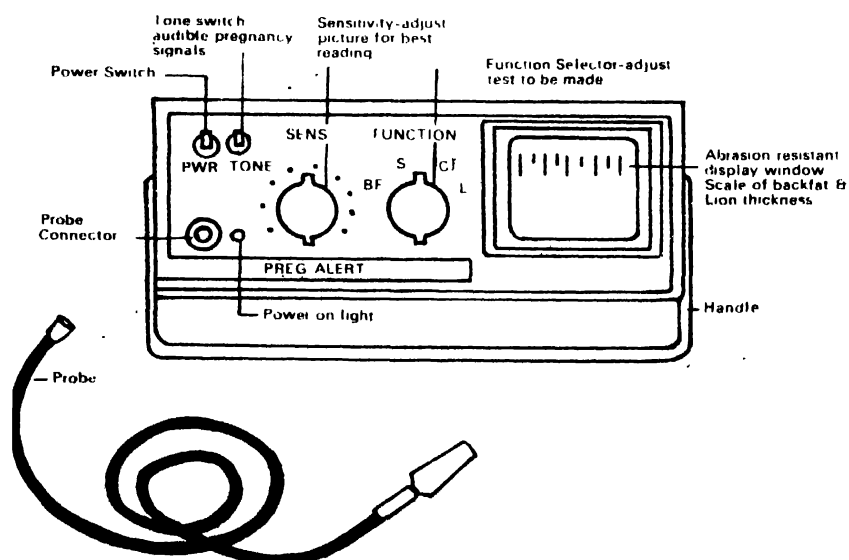


Fig. 1. Operating controls of PregAlert

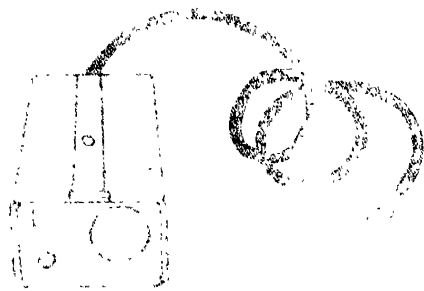


Fig. 2. Pregtone

control in the middle. Smear the probe of the instrument and the shaved part of body where probe is to be placed, with adequate amount of mineral oil. The use of mineral oil eliminates air resistance and provides a low resistance pathway for sound waves to travel from the end of probe into the body of the animal. The probe has to be placed from 2.5 cm to 5 cm in front of the flank, halfway between hairline and the teat-line of the animal (Fig. 3). The probe is directed towards a point 1.25 cm away from the backbone on the opposite side and is firmly pressed without distorting the abdominal wall.

Pregnancy is indicated by a signal (spike/echo) appearing in right or third zone of the screen. The height of the spike is dependent upon the sensitivity control setting, fluid wetting of the skin and the size of the animal and thus is not important. A spike of about 1.8 cm height in the third zone, however, is essential in order to trigger the sound tone signal. The sound tone features of the instrument is helpful in that the operator need not continuously watch

the screen. When the signals appear in all the three zones, it is suggestive of a very high setting of sensitivity control.

Whenever the animal is pregnant, a spike will occur in the middle or right (third) zone of the screen together with a sound tone signal.

#### Other uses

In addition to the detection of pregnancy the instrument shown in Fig. 1 can also be used for measurement of thickness of backfat and loin in pig. These two measurements are useful for carcass evaluation in pig industry. The pregnancy in cow and mare can also be diagnosed with this instrument (Table 1).

Early pregnancy diagnosis in small domestic animals is the best way to make profit by lowering the cost of maintenance. This is achieved by identifying the non-pregnant, feed wasting sows and gilts and by selling them while they can fetch good market price. This also avoids

disposal/slaughter of pregnant animals.

The shortcoming of the instrument is that full urinary bladder across the direction of the probe may sometimes give a broad, multi peaked signal in the middle zone and be confused for pregnancy. Rare disease condition, which accompany fluid buildup in the abdomen, may also give false positive, multi peak signals in all the three zones.

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## Cuckoo spit

MANY a naturalist might have come across the conspicuous accumulation of froth on the tender shoots of some plants in spring and early summer months. It is no wonder if people mistake it for cuckoo spit; since the sudden appearance of this spittle-like froth coincides with the arrival of cuckoos. As a matter of fact, it has nothing to do with cuckoos. These soapy bubbles harbour a soft, greenish-yellow insect which sucks the sap of the plant on which it rests. It is the immature stage (nymph) of a Cercopid bug called frog hopper. The vague resemblance of its head to that of a frog's head and its tremendous jumping power helped it acquire its popular name. Adults can jump over a distance of three feet to escape from enemies, whereas the nymphs are

defenceless. So they hide themselves in the frothy material they produce, until they complete their development.

Much scientific work has not been done on the life-cycle stages of frog-hoppers but several investigations have been hitherto made into the method by which the nymph covers itself with the foam for self defence. Let us examine how the anatomy of the nymph is suitable for bubble-blowing. The sides of the abdomen of the insect are downwardly curved and turned into plate-like lobes which overlap forming an air canal below the abdomen. Spiracles, two in each segment, open into this canal. The nymph sucks excess of sap from the plant and a portion of the unassimilated sap, mixed with waste products, is discharged in the form of

Table 1. Ultrasonic pregnancy diagnosis

Species	Time when the pregnancy can be diagnosed in days
Swine :	30-60
Sheep :	
Single fetus	65
Twin fetus	55
With skilled operator	60
Cow	120-150
Mare	120-150



Fig. 1. A frog hopper

a clear fluid from the alimentary canal. This fluid oozing out of the anal orifice covers the undersurface of the body and fills the space between the latter and surface of the plant. Literally, the young frog hopper bathes in a pool of clear fluid. Now some waxy substance secreted by certain glandular cells present near the tip of the abdomen on the sides of the seventh and eighth segments exudes through minute pores. This mixes with the clear fluid to increase its consistency so that it can hold for a longer time air bubbles formed soon afterwards.

The nymph now lifts its abdomen off the fluid. The previously overlapping lobes below the abdomen are stretched apart to open the air canal wide so that a current of air can be

let in. Air is needed for respiration as well as bubble-blowing. Contraction of abdominal segments squeezes the air out drawing the liquid film in the form of a bubble. Immediately, the tip of the abdomen is submerged in the pool of liquid to release the bubble into the liquid. This procedure is rapidly repeated in quick succession until the pool of liquid is transformed into a mass of bubbles. The insect skillfully spreads these bubbles around it using its legs and covers itself entirely with froth.

Destruction of some of the bubbles in the middle of the frothy mass forms an aircell in which the nymph moults conveniently and adult stage is reached. Bubbles are said to be momentary in existence. These frog-hoppers are curiously stretching the life span of bubbles and employing them to make a formidable fort for protection against enemies.

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## Cost savings through castellated sections

EUROPEAN architects originally pioneered the application of castellated sections at a time when the variety of steel sections available from European steel manufacturers was limited. The first application of castellated section dates back to 1910. The castellated section is made by expanding a standard rolled shape in a manner which creates a regular pattern of holes in the web—the definition of ‘castellated’ being ‘built like a castle, having battlements, or regular holes in the walls, like a castle’.

Thus castellated sections are fabricated first by cutting through the web of standard rolled beams in a regular alternating pattern as shown in Fig. 1a. Then the two halves of the rolled section are rejoined by welding after offsetting one portion so that the high points of the web pattern come into contact (Fig. 1b). This results in a open web beam of considerably greater depth than the initial rolled shape. Sometimes design considerations necessitate an even greater depth of section and this can be

achieved by adding plates to the ‘tee’ sections so forming octagonal instead of hexagonal apertures as shown in Fig. 1b. These sections can be used as beams, columns and chassis for heavy goods vehicles.

Castellated sections provide the following advantages: (1) Lighter sections—the castellation procedure forms an increase in depth of the basic section of approximately 50 per cent. If it is assumed for example, that a beam may be used to span 20 times its own depth, then castellation will give a corresponding 50 per cent increase in permitted span as compared to the parent section. The moment of inertia is 3.375 times greater and the section modulus is increased by 2.25 per cent; (2) High strength to weight ratio; (3) The pattern of holes in the web presents an attractive appearance for beams exposed to view; (4) The web apertures are, furthermore, becoming ever more functional with the increase of piping, conduits and ductwork in modern construction. At a time when services costs make up an ever increasing proportion of overall building costs, it is often important for the architect to be able to employ structural elements which will readily accommodate such services. Castellated beams are more suitable in such circumstances and in many cases, the need for expensive false ceilings is eliminated; (5) Due to the lightness of these beams, foundation costs are reduced; for the same reason these structures are suitable for poor soil conditions also; (6) Painting cost is cut; and (6) Tapered sections can be fabricated easily. In spite of the above advantages of a castellated section it has yet to become very popular in India because of the cost of flame cutting and rewelding of the web. Thus if the cost of fabrication is favourable then castellated sections can be used.

Castellated sections are much in vogue in many parts of the world. Fig. 2 shows a factory building in

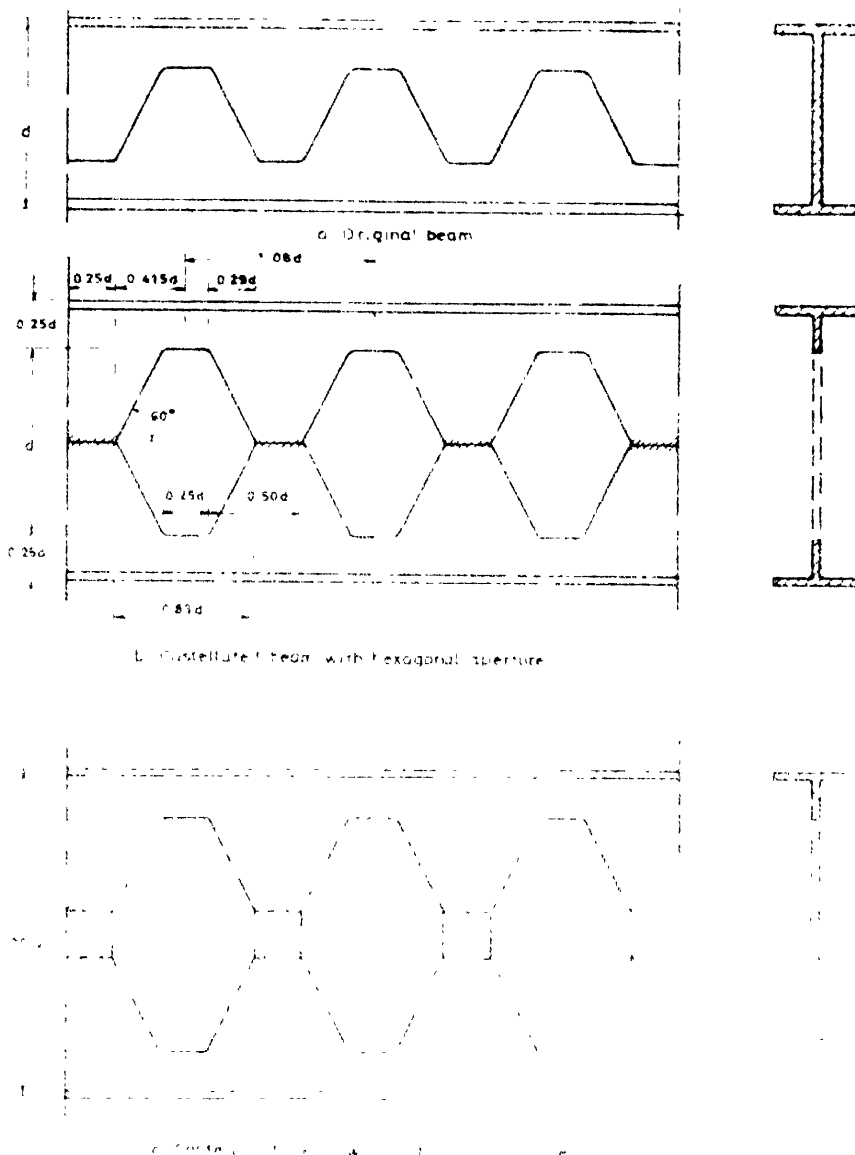


Fig. 1. Details of standard castellations

West Germany using castellated girders. Castellated beams have already been used in the factory buildings of the Indian Institute of Technology, Madras. Applications of castellated sections include use in multistorey buildings, crane girders, industrial buildings, portal frames, light-duty automobile chassis and stiffening girders in ship structures with added advantage of passage for pipes and ducts.

The castellations introduce periodic variation in section properties and hence their analysis is very complicated. The increase in depth in castellated beam makes them prone to elastic lateral buckling. Even the calculation of deflections is rendered difficult because of the variation in section properties. However, the introduction of electronic digital computers and the use of finite element methods have changed



Fig. 2. A factory building in West Germany using castellated girders

the picture and it is now possible to analyse these frames more accurately. Computer programs have been developed at the Indian Institute of Technology, Madras, which can be used to analyse and design these sections efficiently.

The production of these sections has already been undertaken by some private companies in India. The Indian Standards Institution is currently preparing a draft standard for the design of castellated sections in design offices. There is no doubt that these sections will be used in our building industry to achieve economy in steel which is a scarce material in India.

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Int. Sci. News

## Dr. G. K. Koul

AS in human beings, sterilants are used to control the population of insects which are harmful to food production. Recently, non-toxic sterilants have been discovered, which have opened up new avenues in the field of insect control. The researches of Dr. Gopender Krishan Koul concern this new field. The 1979 INSA Young Scientists' Medal has been given to him for his significant contributions in the same. Although he has done research in many related fields, he considers this piece of research work his best for he feels that that part of work a scientist feels to be outstanding which has brought him recognition. His researches concern reproductive biology



Dr. K. Koul

of some non-mammalian vertebrates, investigation into the chemistry of non-toxic plant products for insect control, and their mode of bringing about sterility among insects. Considering the potential his researches have on insect control he has put in considerable labour to understand it thoroughly.

Koul was born on April 14, 1949, in a middle class family at Srinagar, Jammu and Kashmir. His father was initially a science teacher (who later joined Defence services) and it was due to him that he took up science as a career. After graduation

in 1968, he obtained M.Sc. from Allahabad University and Ph.D. from Kashmir University. Presently, he is a Senior Scientific Assistant at the Regional Research Laboratory, Jammu. Dr. Koul thinks that "we can do a lot even within the existing facilities, if only mental outlook is changed". He thinks that science is already popular in the country and there is no need to do anything about it, but at the same time, he laments that there should be less gap between what he calls "big" and "small" scientists.

DILIP M. SAIWAL

### VI Annual Conference

## Orissa Association for Advancement of Science

THE sixth annual conference of the Orissa Association for Advancement of Science was held in the Ravenshaw College, Cuttack on the 18th and 19th October, 1979. M. K. Rout in his presidential address entitled "Economic development, population growth and science", stated that population growth in the world averages 2%, the Indian index being 3%. A population growing at 1%, doubles in seventy years, at 2% doubles in 35 years and at 3.5%, doubles in 20 years. In six and a half centuries from now, there will be one human being standing on every sq. ft. of land on earth.

S. C. Bhattacharya, Director, Bose Institute, Calcutta in his address to the conference dwelt upon the chemistry of scents. He stated that 0.3 gm of musk is obtained by killing a musk deer, *Moschus moschiferus* living in the Himalayas. The odour of sandalwood contains 135 chemical constituents. Human nose is so sensitive that it can detect a smell at a dilution of 0.000,000,000,000,01. A man suffering from cold can smell odour

upto a dilution of 0.000,000,01.

S. Misra, Ex-Vice-Chancellor, Utkal University, addressing the 200 scientists from different institutions in the State, stated that since scientific knowledge doubles every ten years, a progressive country must keep track of the most recent scientific developments in the world.

Altogether 154 papers were presented in the nine sections, viz., Zoology, Botany, Chemistry, Mathematics, Geology and Geography, Psychology and Educational Sciences, Physics, Agricultural Sciences and Engineering & Metallurgy.

A general symposium on man in the services of mankind besides two symposia in the sections of Chemistry and Zoology were held respectively on "Spectra and Chemical structure" and "Zoological researches in Orissa in the coming decade".

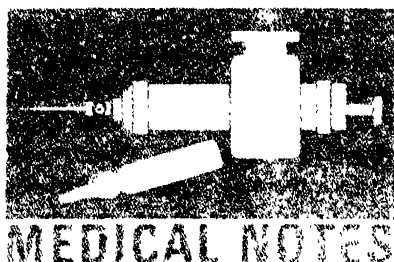
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(Continued on page 209)



## Prostaglandins in cholera and ulcerative colitis

**P**ROSTAGLANDINS are 20-carbon, unsaturated fatty acids. They are present in almost all tissues of the body, are very potent and have varied actions (S.R., July 1977). Recent studies demonstrate that they are also involved in pathogenesis of cholera and ulcerative colitis.

Cholera is an infectious disease caused by the micro-organism, *Vibrio cholerae*. It causes severe diarrhoea followed by fluid and salt depletion. But, the exact mechanism by which cholera organism produces the symptoms was not clearly known. Recent *in vivo* and *in vitro* studies have shown that cholera toxin induces the gut mucosa to increase synthesis of prostaglandins which cause severe diarrhoea.

*In vitro* studies on small intestine of cats reveal that several prostaglandins and cholera exotoxin (toxin liberated by the cholera organism) induce secretion of water and salts. If used together, the effects of cholera toxin and prostaglandins are additive. *In vivo* experiments in man and rats also show that PGE and cholera toxin cause secretion of water and salts from the small intestine.

Prostaglandin E (PGE) and cholera toxin also cause marked increase in adenyl cyclase activity in the small

intestine (S.R., May 1978). These studies led to the suggestion that cholera toxin may act by stimulating prostaglandins which then increase the activity of enzyme adenyl cyclase. The latter, in turn, may increase formation of cyclic AMP in cells (S.R., May 1978). Cyclic AMP may then increase permeability of cell membrane and thus increase secretion of water and salts by intestine. Further, it has been found that aspirin and indomethacin, which are known to inhibit prostaglandin synthesis, inhibit cholera toxin induced fluid accumulation in the rat intestine. This lends additional evidence to the theory that prostaglandins are involved in the pathogenesis of cholera.

Ulcerative colitis is an inflammatory disease, involving primarily the mucosa and submucosa of the colon. The disease is peculiar to man, does not appear in epidemic form, is not contagious and relapses frequently. No specific organism, either bacterial or viral, has so far been found to be the causative agent. It has been found that increased amounts of prostaglandins are present in stools of patients suffering from ulcerative colitis. This has led to a belief that

possibly prostaglandins are involved in its pathogenesis. Diarrhoea and other associated symptoms in this disease may therefore be due to an increased production of prostaglandins by gut mucosa. Because there exists some hereditary pre-disposition to ulcerative colitis, a bacterial, viral or immunological stimulus possibly leads to an increased synthesis of prostaglandins by the gut which in turn causes ulcerative colitis. This theory is supported by the finding that salazopyrine, which is an effective remedy to this condition, is an inhibitor of prostaglandin synthesis. Similarly, corticosteroids, which are of immense value in ulcerative colitis, are also now known to inhibit release of prostaglandins.

Full understanding of the involvement of prostaglandins in the pathogenesis of cholera and ulcerative colitis may have, in the long run, far reaching therapeutic implications.

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## Actinomycin-D inhibits kidney cancer

**T**HE possible role of Actinomycin-D in the specialised therapy of kidney-tumor (Hugo and Russell, *Pharmaceutical Microbiology*; Ed. 1, p. 133, 1977) has recently been well established at the *International Symposium on biological preparation in the treatment of cancer* held in London in 1978. According to reports, a highly malignant, congenital kidney-tumor—also known as Wilm's tumor—can be inhibited by the abi-

lity of actinomycin-D to prevent transcription of RNA by binding specifically to helical double stranded DNA (Fig. 1). J. H. Bradenburg and coworkers at Gotterfried J. Biochem. Laboratory, Wisconsin (U.S.A.) reported that tumors are activated metabolically by an enzyme system which is genetically controlled by DNA. Reich *et al.* suggested that actinomycin prevents strand separation of helical DNA and suppresses

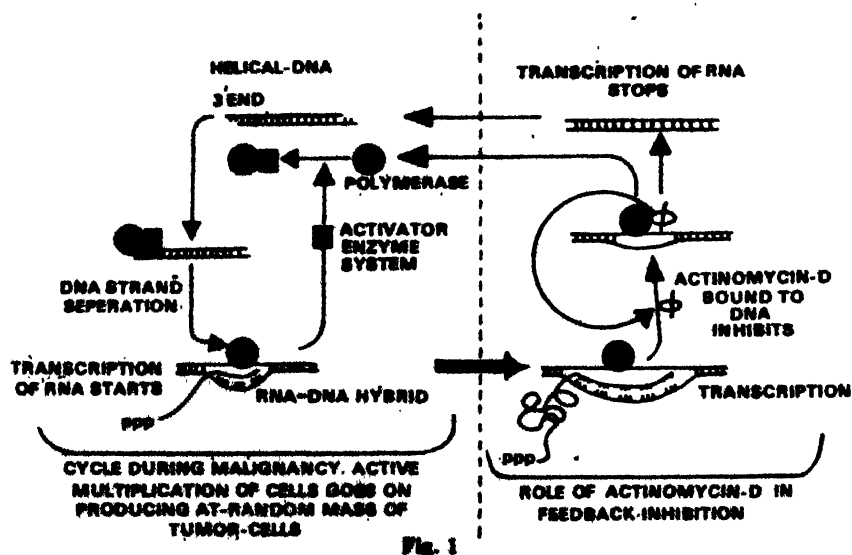


Fig. 1

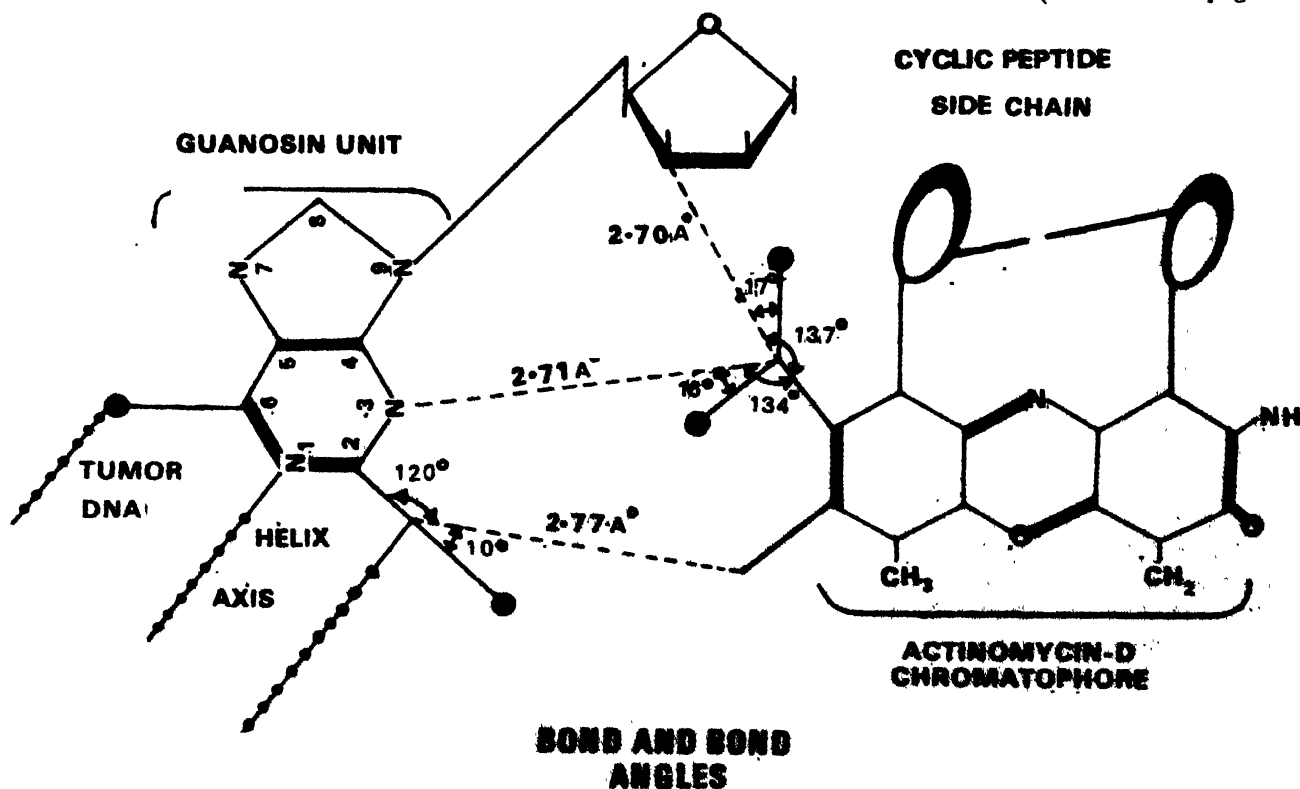
DNA polymerase activity at the corresponding concentrations rendering thereby whole of the enzyme synthesis clocked (Fig. 1). Probably activity of this drug against the RNA synthesis is due to its ability to form complexes with DNA.

The binding to double-stranded DNA or synthetic polynucleotides depends on the presence of guanosin (G) base. Polynucleotides without G are unaffected by actinomycin, e.g., poly d(A-T) will effectively code for RNA synthesis in the presence of

actinomycin-D. The fact that kidney tumors are inhibited by actinomycins further unfolds the mystery that such tumors in their DNA are having guanosin (G) in such a dimensional configuration which enables actinomycin to become tightly bound at the site, blocking thereby subsequent transcriptions (Fig. 2).

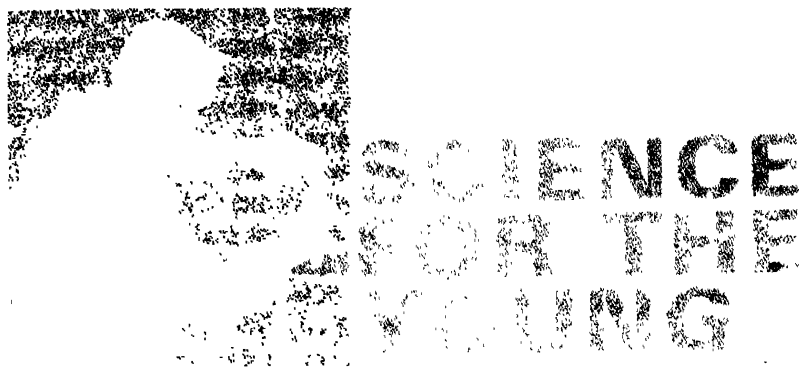
The structure of actinomycin-D has been determined by X-ray measurements on the crystal. Nuclear Magnetic Resonance Spectroscopy (NMR spectroscopy) indicates that the configuration is largely retained in solution. The molecule is essentially T-shaped. Its phenoxanine chromatophore is planar and the two cyclic peptide rings lie behind it in a plane at right angles to the plane of the chromatophore. The two peptide rings are stabilised in special configuration by H-bonds—one in each ring. Models show that a structure of this kind can bind rather specifically to a DNA helix.

(Continued on page 213)



BOND AND BOND ANGLES

Fig. 2



## Serpents of the sea

**W**HILE the existence of the mythical serpents in the sea have evoked human fascination and fear for long, the fact is that the snakes in the sea—more in number than all the snakes on the earth and most venomous of all the living vertebrates—are but the cousins of cobras and kraits of land. Both have evolved from the elapid stock. Behaviour, anatomy, venom and other aspects of natural history of these animals have remained a mystery even to herpetologists who pay more attention to snakes of the land. Perhaps because they are easily collected and studied.

Varying in size from the 46 cm long Crocker's sea snake of the Solomon Islands to the 3.5m long yellow sea snake in all seas, sea snakes are of 55 kinds found chiefly in the south Asian and Australian coastal waters. No sea snakes are found in the Atlantic Ocean and the Mediterranean Sea or the Red Sea. With the single exception of a freshwater species found in Lake Tall, Philippines, and barring members of the genus *Laticauda*, all are exclusively marine appropriately grouped in a single family, Hydrophilidae.

### Eel or sea snake ?

Sea snakes can be easily known by their compressed bodies and

flat tails. However, the unusually flattened tail simulates the fin of an eel for which a sea snake is often mistaken. The dry, scaly covering of a sea snake establishes its identity and distinguishes it from an eel which has a smooth and slimy skin and a gill pouch.

### Adaptations

Adaptations of sea snakes acquired after millions of years of evolution of their life in water are total, perfect, and complete. Some of their structural changes such as the long flexible and laterally compressed bodies, rudder-like tail, nostrils with their water-tight, valve-like flaps set on top of the head instead of on the sides, are obvious. While they are accomplished swimmers, sea snakes are awkward in their movements on land. Sea snakes are endowed with a specially adapted gland in mouth that helps them get rid of the excess of salt from sea water.

The very extensile right lung partly lined with blood vessels is used for absorption of oxygen and also as a hydrostatic organ. Though sea snakes have to come often to surface for purpose of breathing, they can stay down from two to six hours. It is on record that they are capable of accomplishing dives upto 6m to 55 m or 150 m at a stretch and

in the process control the heart beat and pulse rate.

### Where to find them ?

They frequent coastal belts, and are found in rock crevices, tree roots, and pilings that support houses under water. Night lights shining brilliantly over the sea attract them in large numbers. Sea snakes, like marine turtles, are fond of basking on the surface of water. On days when the sea is calm hundreds of them can be seen from steamers. Some of the coastal species settle on outlying reefs while resting. They gather in great numbers among the roots of mangrove trees in monsoon or when the sea is rough and disturbed during heavy gales. As sea snakes principally feed upon fish, they also swarm estuaries and river mouths in search of their prey.

### Food

Sea snakes feed principally upon fish—mostly eels and smaller fishes which are killed by their powerful venom and swallowed whole. They also eat shrimps and prawns found on the sea bottom. The land going sea snake of Asia (*Laticauda*) traps fish in rock crevices with folds on its body and tightly grips. It is then swallowed. The wide ranging black and yellow sea snake (*Pelamis*) which feeds only on the surface adopts yet another tricky device to attract its prey. While it floats on the surface simulating a stick, the less intelligent fish mistaking it for a floating object, swim underneath it. With a sudden backward motion and a quick sideways strike, the snake secures its meal. Some turtle-headed sea snakes (*Emydocephalus*) of Australia and Formosa have fewer teeth and hence subsist on a meal of fish eggs. They are not adept at catching and swallowing fish.

### Venom

Sea snakes are generally timid and easy going in disposition. They





Fig. 1. Common sea snake (*Erhydrina schistosa*) or peaked sea snake

seldom bite except under extreme provocation. Fishermen consider sea snakes harmless. Otherwise how can one explain the careless way a fisherman picks up these potential killers caught in his net and throws them out casually? Sea snakes do not startle their intruders by a loud hiss and they do not have hood like land snakes. Their fangs are short, grooved and immovable. Their venoms 10 to 20 times as potent as that of a cobra is basically neurotoxic. A man bitten by a sea snake does not complain of instant pain as the

bite is like a pinprick. The symptom-free period lasts from 30 minutes to 8 hours. But his legs slowly get paralysed, vision gets blurred and jaws get locked. He develops respiratory failure and convulsions leading to death within 12 hours of the bite. Though all sea snakes are poisonous, their lethal venom is primarily meant for quietening large preys and secondarily for protection against predators. In fact, certain egg-eating sea snakes never get the occasion to discharge their lethal venom. Some sea snakes like *Laticauda* are so docile that even children in Fiji pick them up to play with. Bites are rare. On the other hand, some sea snakes are easily aggravated and may bite readily if provoked. The only commercial antivenin against sea snake bite is prepared by using the venom of a single species of sea snake.



Fig. 3. Black and yellow sea snake (*Pelamis platurus*)

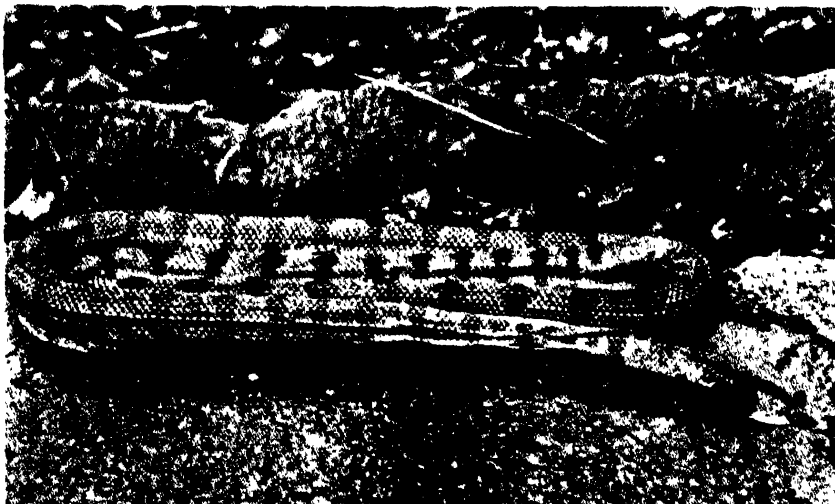


Fig. 2. Yellow sea snake (*Hydrophis spiralis*). Both the adult and young have a yellow coloured belly

### Hazard

Sea snakes are a potential hazard to Asian fishermen. All the south-east Asian countries along the shores of which these sea reptiles abound are densely populated and fisherfolk wade barefoot in muddy shores with their nets. They are prone to be bitten fatally on their wrists, fingers, toes or ankles when they step on a snake or restrain its movements while wading out. Sometimes, sea snakes become a hazard to sea bathers during stormy weather and monsoon. In the Philippines, some resort hoteliers had to fence off the bathing areas of their hotels to afford protection to their

customers from the venomous invaders from the sea. As a measure of precaution, sea bathers and divers should avoid rocky crevices, piers, and old tree roots as they are inhabited by sea snakes.

### Reproduction

All sea snakes barring the amphibious (*Laticauda*), mate at sea and the young ones are born alive in water. Reproduction is not limited to any season or time or the year as is the case with land snakes. Again, females of many species like those of their land allies can store sperm for weeks or even years until the eggs are ripe for fertilization. It is said that pregnant females resort to enmass migration to protected bays to bear their young.

### Common Indian sea snakes

Nearly 20 species occur in Indian waters, majority of them in the Bay of Bengal. Some of the common forms found are the Jordon's sea snake (*Kerlia Jerdoni*), hook-nosed sea snake (*Enhydrina schistosa*), yellow sea snake (*Hydrophis spiralis*), annulated sea snake (*Hydrophis cyanocinctus*) and the narrow headed sea snake (*Microcephalophis gracilis*). Of these, two species, namely, the common sea snake and the annulated sea snake, are reported to be very pugnacious and easily provoked to bite.

### Enemies

Sea snakes have none to fear in their watery kingdom. Even the large omnivorous sharks shun them. They, however, fall an occasional prey to sea eagles. These birds pick up the snakes from waves, beat them with their wings and rip open their flesh with their beaks and feast upon them.

### Exploitation

At first, it is the beautifully patterned skin of these snakes that was in

great demand. The meat and soup of these deadly reptiles are a great delicacy in Japan. Apart from its edible meat, the gall bladder of sea snakes has found a medical use in curing stomach trouble, skin diseases and as an aphrodisiac. With half of the world's known sea snake population swarming our waters, it is

time we exploited this easily available natural resource for commercial gain and for earning valuable foreign exchange. To start with, surveys of potential fishing grounds of these snakes should be undertaken.

T.S.N. MURTHY  
Zoological Survey of India  
Madras 600 028

## What do you know about nine ?

**W**HAT is the greatest number, say, with five digits? Certainly, it is the number in which the number nine is repeated five times, that is, 9 9 9 9 9. Here are some curiosities of the number nine.

The first ten members of the number system are :

0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

The first and last members when added give

$$0 + 9 = 9$$

The second and the last but one member give

$$1 + 8 = 9$$

and so on upto  $4 + 5 = 9$ .

The sum of the members 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 is equal to 45 which, when the digits are added gives

$$4 + 5 = 9$$

If 9 is multiplied by any number, the result is 9. For example,  $9 \times 12 = 108 \rightarrow 1 + 0 + 8 = 9$  and

$$9 \times 213 = 1917 \rightarrow 1 + 9 + 1 + 7 = 18 \rightarrow 1 + 8 = 9$$

Now take a number with unequal digits. Reverse the digits to form a new number. The difference of these numbers is 9. For example,

(i) Take the number 74. The number formed by reversing the digits is 47.

$$\text{So } 74 - 47 = 27 \rightarrow 2 + 7 = 9.$$

(ii) For 132, the reverse number is 231.

$$\text{So } 231 - 132 = 99 \rightarrow 9 + 9 = 18 \rightarrow 1 + 8 = 9$$

(iii) For 7341, the reverse number is 1437.

So  $7341 - 1437 = 5904 \rightarrow 5 + 9 + 0 + 4 = 18 \rightarrow 1 + 8 = 9$  and so on for the numbers with higher digits. This rule applies to more general cases also.

Now take any number. Let the digits be re arranged to form new numbers. The difference between the numbers becomes 9. For example,

(i) Take the number 132. The new numbers are 123, 213, 231, 312 and 321.

Now  $132 - 123 = 9$  and  $231 - 123 = 108 \rightarrow 1 + 0 + 8 = 9$ , etc. The rule is also valid when two digits are equal.

(ii) Take the number 1234. The new numbers are 2314, 2341, 2134, etc.

$$\text{Now } 2314 - 1234 = 1080 \rightarrow 1 + 0 + 8 + 0 = 9$$

and

$$2341 - 2134 = 207 \rightarrow 2 + 0 + 7 = 9$$

The rule is also valid when three digits are equal. It may be extended to numbers with higher digits.

The well-known Kaprekar's constant (See *Science Reporter*, June 1979) is 6174, which also becomes 9 i.e.,  $6174 \rightarrow 6 + 1 + 7 + 4 = 18 = 1 + 8 = 9$ .

Now, consider numbers of two digits, the individual digits of which add up to 9. The numbers are 18,

## SCIENCE FOR THE YOUNG

27, 36, 45, 54, 63, 72, 81 and 90.

This is clearly a family of Arithmetic Progression of 9 members with the common difference 9. When the sum of the digits is 8, the numbers are 17, 26, 35, 44, 53, 62, 71, 80, 98 which obey the above conclusion. Same results are obtained when the individual digits of the numbers add upto any of the numbers from 1 to 7.

Palindrome numbers are those which read the same when viewed from the right hand or left hand side. In other words, the number and its reverse number are the same. Now, the family of Palindrome numbers whose sum of the digits adds upto 9 are 171, 252, 333, 414, 585, 666, 747, 828 and 909.

This is a family of 9 members and the difference between any two

members adds up to 9. For example,  $252 - 171 = 81 \rightarrow 1 + 8 = 9$  and

$$585 - 414 = 171 \rightarrow 1 + 7 + 1 = 9$$

Also, the difference between any two numbers in the above two sets also adds upto 9. For example,  $252 - 81 = 171 \rightarrow 1 + 7 + 1 = 9$

The Palindrome numbers of four digits, whose sum of digits adds up to 9 are 1881, 2772, 3663, 4554, 6336, 7227, 8118 and 9009.

This is a family of Arithmetic Progression with common difference  $= 891 \rightarrow 8 + 9 + 1 = 18 \rightarrow 1 + 8 = 9$ .

The rule applies to Palindromes with higher digits.

AJOY ROY CHOUDHURY  
Deptt. of Mathematics  
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Assam

respectively. They have to reach the common destination. The first man reaches the destination at 7 P.M., the second at 9 P.M. When did they set out for their journey and how far was the destination from their starting place ?

P.K. MUKHERJEE  
Lecturer in Physics  
Deshbandhu College  
Kalkaji, New Delhi

## Science quiz

1. A sprayer works on :  
(a) Archimedes principle, (b) Boyle's law, (c) Bernoulli's principle.
2. Venturimeter measures :  
(a) Specific gravity of a liquid, (b) rate of flow of water through a pipe, (c) thermal conductivity of a substance.
3. Conductivity of a semiconductor :  
(a) decreases with increase in temperature, (b) remains unchanged with change in temperature, (c) increases with increase in temperature.
4. Threshold frequency for photo-electric emission depends on :  
(a) intensity of incident light, (b) nature of the material, (c) potential difference between the emitter and the collector.
5. A satellite that appears stationary from the earth revolves round the earth in an orbit of radius :  
(a) 35680 km, (b) 20000 km, (c) 45500 km.
6. Phobos is a satellite of :  
(a) Jupiter, (b) Neptune, (c) Mars, (d) Saturn.
7. Titan is a satellite of :  
(a) Jupiter, (b) Saturn, (c) Mars, (d) Neptune.

(Continued on page 213)

## Brain teasers

### 1. Points and the hexagon

In Fig. 1 are shown seven points lying inside a hexagon. By drawing three straight lines divide the hexagon into seven sections. There must be one point in every section.

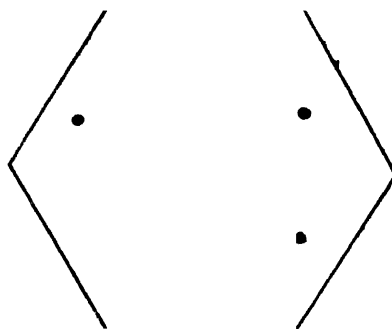


Fig. 1

### 2. The intersecting circles

Fig. 2 shows three intersecting circles, a set of three straight lines and nine points. On the circumference of every circle there are four points. You have to insert the digits 1 to 9 in the positions of these points so that the sum of the digits along every line is 17. The numbers on the circumference of each circle must also add to 17.

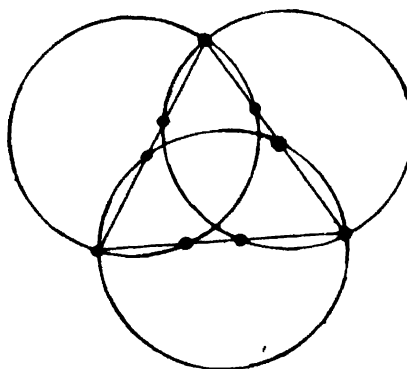
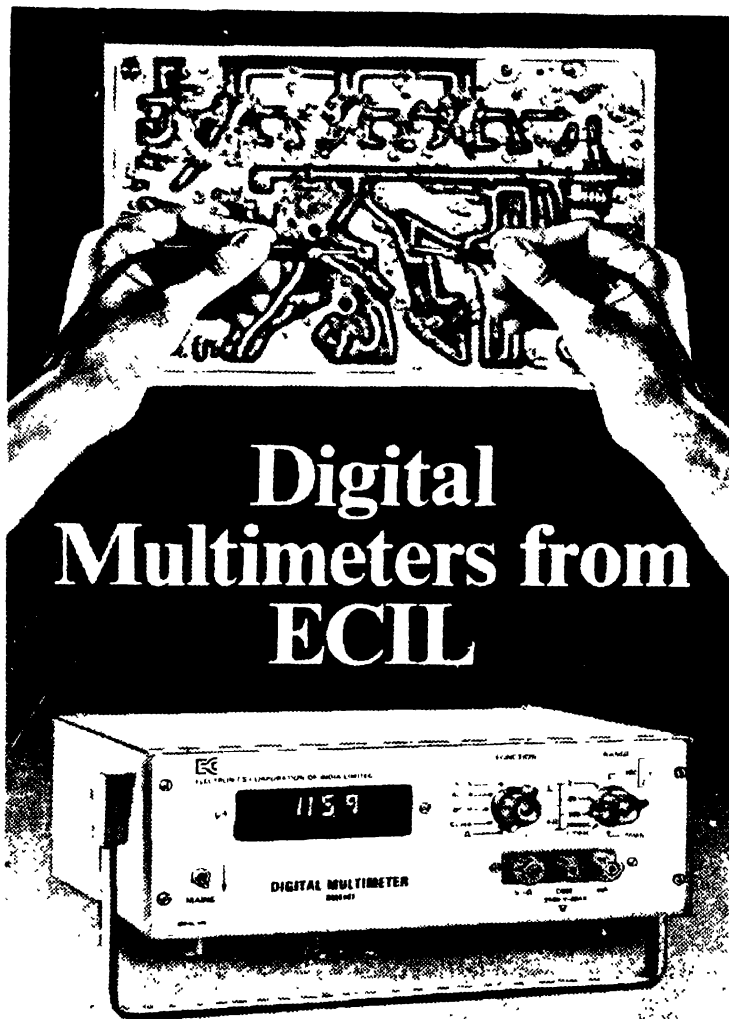


Fig. 2

### 3. Two motorists

Two motorists start from a certain place and drive their cars at speeds of 36 kmph and 30 kmph



The DM6103 and the DM6104 are two digital multimeters for  $3\frac{1}{2}$  and 4 $\frac{1}{2}$  digits respectively. The A/D conversions enable to achieve high accuracy and resolution with the maximum discrimination against undesirable interfering signals.

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- **Auto-zero and Auto-polarity**
- **Protected against momentary wrong setting of function and range switches**
- **Floating input points** permit differential measurements
- **A/D conversion** by dual slope integrating technique

##### 4 $\frac{1}{2}$ Digit Digital Multimeter DM6104

- **Multifunction capability** Measures voltage, both DC (600V) and AC (1000V) current and Resistance
- **Display** Four and half digit in-line seven segments LED devices Max Count 19999
- **Over Range** Indicated by blinking digits 100% over range measuring capability
- **Auto-zero and Auto-polarity**
- **Protected against momentary wrong settings of function and range switches**
- **Floating input points** permit differential measurements
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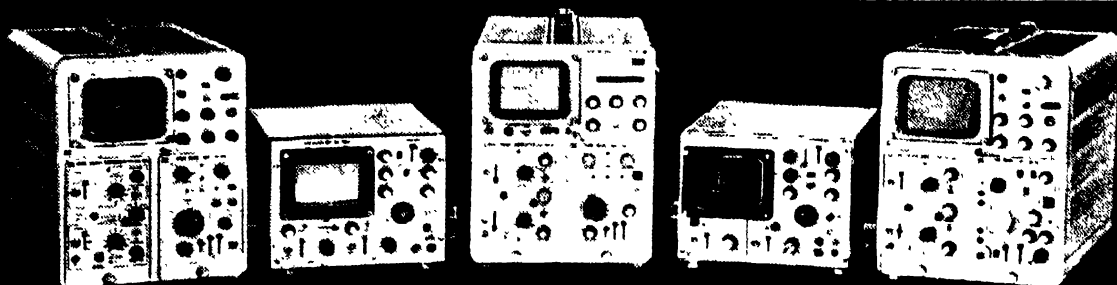
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A variety of plug-ins are available for OS 768A, OS 768S, OS 768 models

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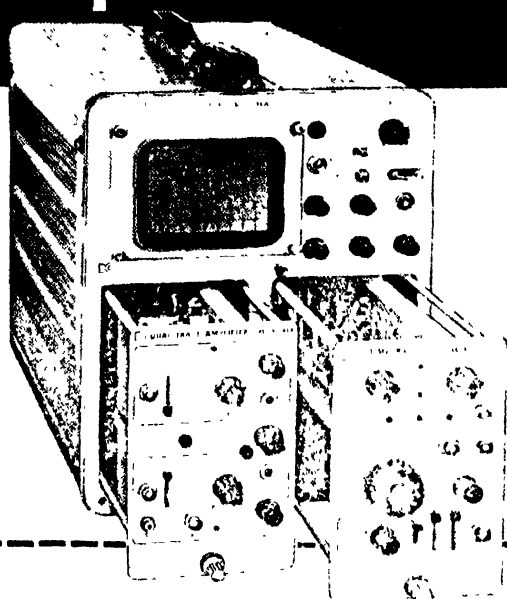
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|----------------------|--|
| Vertical amplifier   | 768A1 Single trace<br>768A2 Dual trace<br>768A4 Four trace<br>768A2A 100MHz Dual trace   |
| Horizontal amplifier | 768B1 Normal time base<br>768B2 Variable delay time base<br>768B1A Normal time base for 100 MHz<br>768B2A Variable delay time base for 100 MHz |

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## Brand name drugs—safer than generic drugs ?

WITH so little publicity given to the "non-proprietary" or the chemical or what is generally known as the "generic" names of drugs, the average consumer today is often totally unaware of their existence. Neither the manufacturers of branded drugs nor the doctors who prescribe them are helpful in dispelling this consumer ignorance. Would you believe it? Ampicillin, a well-known antibiotic, has appeared in the world market under 224 popular labels, but only 24 formulations! The result? Even a knowledgeable consumer invariably goes in for the much advertised brand names, which come beautifully packed and attractively labelled. It is interesting to see what this trend costs the consumer.

But before that, let us see what exactly is meant by a generic drug? Any chemical substance, when it has been proved to have some therapeutic usefulness, is assigned a generic or "official" name. For instance,

acetyl salicylic acid, the world's best pain killer, is officially known as 'aspirin'. A plain aspirin tablet (325 mg) costs only 3 paise, while its equivalent branded products cost three to five times more. Can one justify this additional cost? As far as the manufacturer is concerned, partly yes, to pay for the advertising, the better packaging, labelling, etc. But for the consumer it just means extra payment for practically no extra benefit. Because whether you buy a bottle of plain aspirin or a widely advertised brand, there will be no difference in the anti-pyretic (fever reducing), anti-inflammatory and analgesic (pain killing) quality of the products, provided they are genuine and not spurious. (Any genuine product that claims to be aspirin must necessarily meet the official standards set for that drug.) Claims that the branded products are more effective and even safer are ambiguous and misleading. Some manufacturers mix aspirin with one or more ingredients and present a new product to the public, which they claim is safer and more effective than the plain aspirin. But such combinations have no clinical advantage over single component products. So it is pointless to go in for anything more costly than plain aspirin, for the variety of ailments that this drug is good for.

To take another example : tetracycline, a widely used antibiotic, is marketed under various brand names. Doctors in their prescription may use either the generic name (tetracycline) or any one of its brand names. The latter of course costs much more than the former, although both must necessarily satisfy the requirements of safety, strength, purity and effectiveness, as laid down by the drug laws.

One misconception widely prevalent among consumers is that only large reputed firms produce brand name drugs while small unknown companies are relegated to the manufacture of generic drugs. The

truth is that a drug company, whether large or small, can market its products under generic or brand names or both. In fact, some large companies distribute under their brand names products manufactured, packaged and labelled by firms that make generic drugs. They may also purchase drugs in bulk from other firms and then make the final dosage forms. Since drug labels are not required to indicate the name of the original producer of the drug, neither consumers nor pharmacists are normally aware that a drug carrying the brand name of one company was actually made by another.

It is obvious from the above that there should be only one standard for any drug in the world market. New York State in the U.S.A. has recently published a drug list which is an accurate guide to prescription drugs which are considered by the U.S. Food and Drug Administration as safe, effective and equivalent in therapeutic performance. The list helps pharmacists to substitute less expensive generic drugs for equivalent higher priced brand name products. The list has been prepared and issued as part of a new state programme to reduce prescription drug costs without sacrificing quality. According to Donald Kennedy, Commissioner of Food and Drugs, U.S.A., there is no consistent difference in quality between drug products sold by large and small firms or drugs sold under a brand name or generic name, provided both have been subjected to the necessary quality control in production, packaging and storage. The preliminary quality control before a drug is allowed to be marketed includes tests conducted by the producer in several phases—in the laboratory, in animals, and finally in human volunteers—which demonstrate the safety and effectiveness of the drug for intended purpose.

In this context the notification by the Government of India that all  
(Continued on page 213)

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## Lactase—applications in dairy industry

**L**ACTASE ( $\beta$ -D-galactosidase) is an enzyme that hydrolyses the disaccharide lactose (milk sugar) to its constituent monosaccharides, glucose and galactose (Fig. 1). It is widely distributed in nature; it exists in animal tissues, plants and microorganisms (Table 1). But, due to various reasons, only the lactase from microorganisms can be used commercially.

The rationale for using lactase in dairy industry is the nature of changes that it brings about in the chemical and physical properties of milk and milk products as a result of lactose hydrolysis.

An attractive method of preserving whole milk is by freezing milk concentrate (the volume is reduced to about one third of that of the whole milk). It can be kept for much longer period than fluid milk kept under refrigeration conditions. Besides, the reconstituted milk from this concentrate gives a flavour virtually indistinguishable from that

of fresh milk. However, concentrates prepared from normal milk have a tendency to thicken and coagulate on standing due to crystallization of lactose at low temperatures. The concentrate prepared from lactose-free milk by the use of lactase improves the stability of the concentrates during storage at low temperatures. Similarly, the keeping quality of skimmed milk concentrates prepared from the lactose hydrolysed skimmed milk is higher.

A large segment of the population cannot digest milk because of the lack of enzyme lactase in their intestines. They develop stomach cramps, flatulence, or diarrhoea after the consumption of milk or milk products. This deprives them of these important sources of proteins, vitamins and minerals. The problem of lactose intolerance can be overcome by the removal of lactose from milk and milk products before these are consumed by lactose-intolerant persons. The ideal approach for the removal of lactose in milk is its hydrolysis to glucose and galactose by the enzyme lactase (For details see *S.R.* July 1979).

Whey, a byproduct of cheese, has high BOD (Biological Oxygen Demand) value which makes its disposal rather difficult. At present, it is not a serious problem in India, as the dairy industry is not so well developed. However, in future we may face this problem. The nutritive value of whey is very high because of the presence of essential amino acids (lysine, tryptophan, and methionine). Therefore, as syrup or in the dried form, it can be supplemented in different foodstuffs to increase their nutritive value. But the presence of high amount of lactose (70 % of solids) in whey makes these preparations unsatisfactory. They cannot be stored at low temperatures, as the crystallization of lactose imparts to these products a sandy or gritty texture. It also leads to the formation of protein clumps by destabilizing

Table 1. Occurrence of lactase

### Animals

Snails and intestines of rabbit, dog, sheep, goat, calf, boar, bull and rat; human saliva, and crop of chicken

### Plants

Kefir grains; tips of wild roses; seeds of alfalfa, coffee and soyabean, almond, rosaceae

### Microorganisms

*Escherichia coli*, *Saccharomyces fragilis*, *Saccharomyces lactis*, *Lactobacillus bulgarius*, *Lactobacillus helveticus*, *Aspergillus oryzae*, *Aspergillus flavus*, *Aspergillus niger*, *Streptococcus lactis*, *Mucor pusillus*, *Bacillus megaterium*, *Neurospora crassa*, *Streptococcus cremoris*, *Streptococcus thermophilus*, *Leuconostoc citrovorum*, *Macrophomina phaseoli*, *Sclerotium tuliparum*.

Table 2. Relative sweetness of 10% aqueous sugar solutions

Sugar	Sweetness (%)
Sucrose	100
Lactose	40
Glucose	75
Galactose	70

the protein-protein interactions. The treatment of whey with the enzyme lactase can not only overcome these problems, but can make these products innocuous for consumption by lactose intolerant persons as well. Moreover, glucose and galactose produced as a result of hydrolysis of lactose are sweeter (Table 2), and thus obviate the addition of extra sweeteners in the food products. Furthermore, the hydrolysed whey can be used as feed for animals and poultry without producing the symptoms of lactose intolerance.

Whey can also be used as a fermentation substrate, especially for the production of single cell protein and alcohol. The first step in these processes is the utilization of lactose present in it. But relatively few organisms are known to ferment lactose

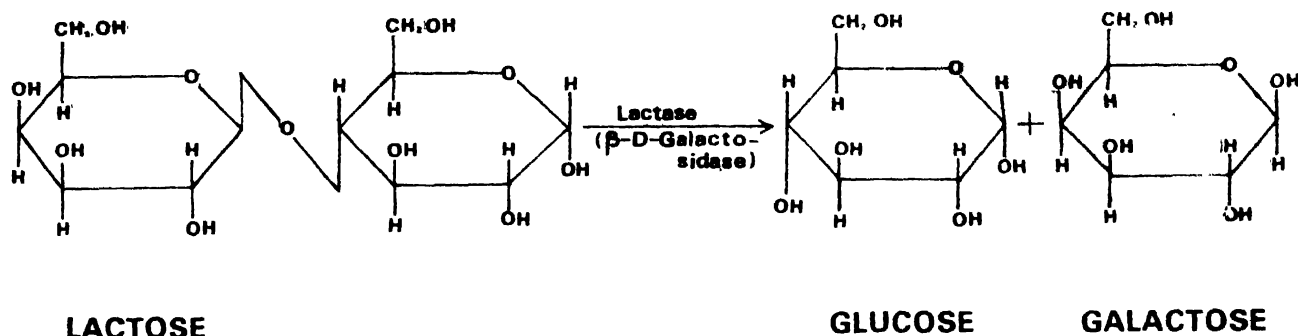


Fig. 1

American scientists, Leary and co-workers (1975) evaluated several yeasts for the production of alcohol from whey. They found *Kluyveromyces fragilis* to be the most efficient one. It converts 55% of lactose of whey to alcohol. The low conversion level was attributed to inability of the yeast to tolerate high alcohol concentrations. Whey with its lactose hydrolysed can use non-lactose fermenting organisms such as *Saccharomyces cerevisiae*, which is used in the production of wine and beer because of its ability to withstand relatively high alcohol concentrations.

The use of lactose hydrolysed milk modifies the process of manufacture of various cultured products. The rate of development of acid increases and the time of curd formation decreases by the use of lactase treated milk. Yogurt prepared from lactase treated milk takes less time to set because of faster acid development. The improvement in the quality of cultured products (cheese, yogurt) is supposed to be due to the increase in the levels of enzyme released by higher bacterial population when glucose is available as a result of lactase treatment.

Despite the versatile applications

of lactase in dairy industry, its utilization has been hampered by the high cost of the enzyme. However, recent developments in immobilized enzyme technology holds potential for successful use of lactase in dairy industry by significantly reducing the cost, as it permits the reuse of enzymes.

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## NEWS AND NOTES (Continued from page 196)

### Solar eclipse affects plants

A team of plant biologists consisting of Prof. G. P. Mishra, N.K. Soni and A.S. Mishra along with their 11 research associates carried out a series of experiments from 12th Feb. to 20th Feb. 1980 in order to study the effect of solar eclipse on plants at the University of Saugar, Saugar. Experimental sets covered such aspects as opening of flowers, seed germination and embryological changes in garden plants (*Salacia coromandelica* and *Argemone mexicana*—S.M. Kazmi, *Pisum sativum*, *Linum usitatissimum* and *Den-*

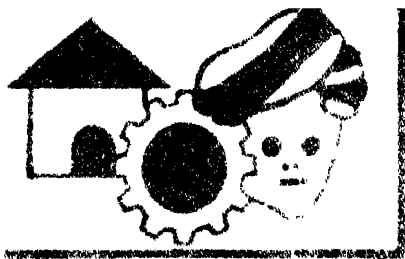
*drocalamus strictus*—A.K. Kher and Kalpna Mishra); endogenous respiration, mycelial growth and combinations of different strains of fungi (*Botryodiplodia theobromae* isolates—S. M. Kazmi; *Hemicola insolens* and *Sporotrichum thermophile*—Veena Trivedi, *Phytophthora parasitica*—Satish Chile; *Rhizopus* sp. and some sterile mycelia—Neeraj Saxena); development of pigments (*Euphorbia geniculata*—Mala Saraf and Satish Chile); pollen germination and tube development (Ela Tiwari); cytological observations (*Allium cepa* and *A. sativum*—Premalita Oswal); plant height and flower cycle (Ashutosh and Amitabh).

Some of the most remarkable

observations are as follows:

1. Sudden increase in height of tested plant species, 2. Decrease in chlorophyll content, 3. Initiation of sporulation in one of the tested fungal sterile mycelia, 4. Suppression of fungal growth and rate of respiration, and 5. Complete inhibition of spore germination of thermophilic fungi during partial eclipse while stimulation during totality. Other observations and scientific data are in a state of analysis and will need some time in their interpretation by workers.

G.P. MISHRA  
Head, Deptt. of Botany  
University of Saugar, Saugar (M.P.)



## Pepper processing unit

**T**HE Central Food Technological Research Institute (CFTRI), Mysore, has prepared a project report on the establishment of a pepper powder processing unit for a public sector organization in Kerala.

India has been exporting pepper powder mostly to countries in West Asia; during 1977-78 44,500 kg of the powder valued at Rs. 1.2 million were exported. The demand for pepper powder in the domestic and international markets is growing. The brands with assured and uniform quality have special advantage in world markets.

A large share of the black pepper exported from the country is reported to be processed in the importing countries and sold to the ultimate consumer as pepper powder in unit packs.

The proposed pepper powder manufacturing unit will have an installed capacity of processing one tonne of black pepper per day.

## Wet dehulling process for sesame seeds

**T**HE Central Food Technological Research Institute (CFTRI), Mysore, has developed a wet dehulling process for easy removal of the husk from sesame seeds, thereby making it possible to obtain from them a good-quality oil and meal.

High-grade sesame oil can be obtained from dehulled seeds. The protein-rich cake flour is useful for enriching various food preparations.

Nearly 77% of an estimated annual production of 4,00,000 tonnes of sesame seeds in the country is used for oil extraction, and some quantity is used in a variety of sweets, confectionery and bakery products after removal of the fibrous husk. The seeds are required to be dehulled to

remove the cuticle, which imparts a dark colour and bitterness to the product. The traditional practice of dehulling the seeds is by soaking the seeds overnight in water, followed by partial drying and rubbing against a rough surface. This is laborious, time-consuming, and is suitable for handling only small quantities.

In the CFTRI process, the seeds are pre-cleaned in a machine and then chemically treated, washed and decuticled. The wet dehulled seeds are dried mechanically.

All the major equipment including units for precleaning, dehulling and destoning, and the drier are indigenously available.

## Neem put to new uses

**S**CIENTISTS at National Chemical Laboratory (NCL), Pune, have isolated from neem a certain fraction which prevents egg laying by some insects completely. Application of the active component has been found to completely prevent egg laying on treated surfaces by the potato tuber moth and some species of mosquitoes. The discovery is a significant breakthrough because it is the larvae emerging from the egg which cause all the damage in case of potato tuber moth and similar insects like butterfly and other moths. Since

some moths cause severe crop losses, prevention of egg laying by them on crops or stored commodities would save them from insect damage.

Neem seeds and leaves are known to possess medicinal, insect repellent and other beneficial properties. NCL findings have identified new neem products which by themselves, or in combination with other neem components, could provide safe and environmentally acceptable effective pest control agents. Field trials against potato tuber moth and other crop pests are already in progress.



## BOOK REVIEWS

**MICROWAVES** by K. C. Gupta, Wiley Eastern Ltd., 4835/24, Daryaganj, New Delhi-110002, 1979, Pp. 242, Rs. 16.50.

**E**LECTROMAGNETIC waves with frequencies varying from 100 Mc to 300 Mc or with wavelengths in the range 3 cm to 30 cm are referred to as microwaves. The generation of these very high frequency waves becomes difficult by the conventional electron tubes especially in view of the transit time effect. This necessitates the designing of special type of tubes for operation at and generation of microwave frequencies. These tubes include the multicavity and reflex klystrons, the travelling wave tube (TWT), the backward-wave oscillator (BWO), and the magnetron. These various types of tubes are discussed in Chapter 3.

Chapter 1 gives a brief introduction to microwaves and their potential applications. A brief review of transmission lines, wave guides resonant cavities is included in Chapter 2, which also discusses the electro-magnetics of waveguide and cavity resonators in terms of Maxwell's equations. Description of improved solid state devices for operation at microwave frequencies forms the subject matter of Chapter 4. Various devices discussed in the chapter include GaAs Schottky-barrier gate field effect transistor (MESFET), transferred electron devices (TED) including Gunn diodes, IMPATT (Impact Avalanche Transit Time) and TRAPATT (Trapped Avalanche Transit Time) devices.

The analysis of electrical networks at lower frequencies is generally carried out in terms of an impedance or an admittance matrix which uses Kirchhoff's laws and voltage-current concept. However, conventional definitions of voltage and current become vague at microwave frequencies. Therefore, for the analysis of microwave networks, an alternative scattering matrix formulation is resorted to. A concise account of this formulation appears in Chapter 5 which also includes a few representative expressions of scattering matrices for networks of practical interest.

Microwave measurement techniques are described in Chapter 6. These include methods of measurement of impedance and power as also microwave frequencies. Chapters 7 to 9 contain discussions regarding some sophisticated microwave circuit components. The three chiefly used passive circuit components, namely, impedance, transformers, filters and directional couplers are described in Chapter 7. The non-reciprocal ferrite components, e.g., isolators, circulators, switches and modulators which are based for their action on the phenomenon of Faraday rotation in ferrites, are included in Chapter 8. Also discussed are Yttrium iron garnet (YIG) resonators which find extensive use in tunable microwave filters and solid state oscillators.

Besides ferrites, some of the microwave systems use PIN diodes (these diodes have an intrinsic layer of high resistivity placed between a p-type and an n-type of layer). Use of these diodes as control components such as switches, phase shifters, attenuators, modulators and limiters is described in Chapter 9. Also included is the use of transferred electron devices and GaAs field effect transistors in ultrafast logic circuits. These circuits employ sub-nanosecond pulses with major part of their frequency spectrum lying in the

microwave range.

Microwave integrated circuits (MIC) in use today are mostly of hybrid nature. A concise account of hybrid MIC technology along with the description of some planar transmission lines is presented in Chapter 10. The normally used lumped elements (e.g., resistors, inductors and capacitors) cannot be directly used at microwave frequencies because their size becomes comparable to the wavelength. Now it is possible to design and fabricate small sized lumped elements too, thanks to the photolithography and thin film technology. This forms the theme of Chapter 11.

The concluding Chapter 12 discusses some of the interesting applications of microwaves in non-communication areas as distinct from their conventional applications in radar and communication systems. These are industrial, scientific and medical applications of microwaves. Some of the industrial applications include thickness measurement of wire diameter and monitoring and measuring of moisture content in paper and textile industry. Also discussed are applications of Doppler motion sensors and of microwave heating. The latter is based on the principle of dielectric heating and finds extensive applications in microwave ovens for cooking and in medicine for diathermy, cancer treatment, etc., where it is required to produce heat directly inside the muscles without heating the tissues and the skin outside.

The book uses simple and lucid language. Presentation of the test material is generally good. Complicated mathematical details have been avoided. Bibliography giving references to other source material pertaining to the topic has been added at the end of each chapter. Moreover, to increase readers' understanding of a topic, a set of problems is included at the end of each chapter. However, in spite of all these plus points, the

book suffers from many printing errors. Indeed some grave errors have crept in Chapter 8. For instance, the Larmor frequency in Eq. (8.4) is defined as  $\omega_0 = \beta |\beta_0|$  but  $\beta$  is not defined in the text. In Sec. 8.3 the parameters  $\mu_1$  and  $\mu_2$  are wrongly defined. In another section 8.10, the sentence 'These garnets show ferromagnetic properties similar to ordinary ferrites' is erratic for ferrites are known to exhibit ferrimagnetic and not "ferromagnetic" properties. A thorough overhauling of the book is therefore warranted. Nevertheless the book is useful for the students of physics and electrical engineering as also for engineers engaged in research.

P. K. MUKHERJEE

**VIEW FROM KANYA** by W. S. Titus, *The House of Letters*, 1368, Kashmere Gate, Delhi, Rs. 22.00.

ULTIMATE science is the beginning of poetry, many have believed. Poetry and science, to a common man, however, are miles apart. They have nothing in common is the general belief. But, what happens when a science communicator turns a poet? A good many of us will hold our breath and say that the result will neither be science nor literature. It is not always so. There are some exceptions. One such exception is W.S. Titus, the well-known science communicator. He writes poems with as much ease as he communicates science to laymen. Though there is not much room for emotions and feelings in science writing, he more than makes up in his poems. He is a man of sensitive vision and expressive emotions. Titus turns to writing poems when he finds life disgusting and nature stimulating him into a new dream land. *View from Kanya* is the second collection of his poems. The poem are brief, brisk and touching. They arouse sentiments in readers and clearly bring before their eyes the beauty of nature and imperfection of man.

**NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS** by M.K. Jain, *Wiley Eastern Ltd.*, 4835/24, Ansari Road, New Delhi-110002, Pp. 443, Rs. 80.00.

IT is said the difference between a mathematician and a statistician is that the former makes statements of the type "if a then b" and the latter "if a then almost b". The topic of the book under review is one of those areas where the mathematician is unable to make any assertions and statistician's approximations are the best that one can expect. Many differential equations that scientists deal with cannot be solved analytically and the calculus of finite differences is often resorted to obtain the numerical solution. This topic is usually confined to one of the last chapters in the text-books at the undergraduate level. But here is a book which exclusively deals with it.

The first chapter is a brief exposition of the basic concepts involved in the calculus of finite differences in general and numerical integration in particular. Only these have been used in the subsequent chapters and the book is self-contained in this sense.

The single step methods approximate the solution using the related first order difference equation. The simple methods based on Taylor's expansion and Runge-Kutta approach fall under this category, which have been discussed in the book, among others. In contrast, the more complicated methods, which use the approximations obtained at initial steps in the subsequent steps to improve the reliability, have been discussed in a separate chapter. The approximations used in numerical methods induce some error in the solution. It is desirable that the accumulation of this error does not assume menacing proportions. This property of stability has been analysed for all the methods.

The tricks involved in the replacement of the differential equation given

the boundary conditions by a set of difference equations, which, in turn, is solved by various methods have been explained adequately. The next three chapters have been devoted to the study of difference methods for solving three specific types of differential equations, parabolic (e.g., classical heat-flow equation), hyperbolic (e.g., vibrating string equation) and elliptical (e.g., Dirichlet problem), which scientists come across very often. Finite element methods use polynomials as approximating functions instead of difference analogues and are easier for computational purposes. The last chapter is a study of these methods.

The prominent feature of the book is its exhaustive bibliography. It also contains abundant examples, some solved to illustrate the methods and some for the readers to try. The basic concepts, however, have been explained sketchily and unless one is familiar with the material in the standard undergraduate textbooks it is difficult to comprehend the book. A good one for the specialists in the field.

RAVINDRA R. RANADE

### Books received

1. **MACMILLAN BRAIN-TEASERS : MATHS** by R.C. Singhal, *Macmillan Co. of India*, 2/10, Ansari Road, Daryaganj, New Delhi-110002, Pp. 61, Rs. 6.75
2. **A HAND BOOK OF SYSTEMS ANALYSIS** by John. E. Bingham and Garth W.P. Davies. *Macmillan*, London [(Available from : *Macmillan Co. of India*, address as above)], Pp. 229, £ 4.95
3. **ESSENTIAL SOLID MECHANICS** by B.W. Young, *Macmillan*, London [(Available from : *Macmillan Co. of India*, as above)], Pp. 250, £ 3.25

## MEDICAL NOTES (Continued from page 198)

It is evident that basic understanding of the exact mechanism involved in the inhibition of kidney tumor will further unfold the possibility of actinomycins and related compounds in the inhibition of many

other types of autonomous and unrestrained tumors.

ANJANA SHARMA  
Microbiology Department  
All India Institute of Medical  
Sciences, New Delhi

and  
ARVIND KUMAR RAI  
Microbiology Division  
National Institute of  
Communicable Diseases  
Delhi-110054

## FOR HER (Continued from page 206)

new drugs should be marketed under their generic names only, is a boon to the consumer. In regard to drugs already marketed, the Government had some time back announced its

intention to permit the sale of only generic versions of five drugs— aspirin, analgin, chlorpromazine, ferrous sulphate and piperazine. However, this new regulation has still not

been implemented on account of various legal requirements.

THANKAMMA JACOB  
Lady Irwin College  
New Delhi-110001

## SCIENCE FOR THE YOUNG (Continued from page 202)

8. 1 Angstrom is equal to :  
(a)  $10^{-10}$  cm, (b)  $10^{-12}$  cm,  
(c)  $10^{-8}$  cm  
9. EEG gives information about :  
(a) heart, (b) brain, (c) lungs

10. Ultrasonic has frequency .  
(a) greater than 20 KHz., (b)  
less than 20 KHz., (c) less than  
20 Hz.

PRADIP KUMAR DATTA  
Institute of Radio Physics & Electronics  
92, Acharya Prafulla Chandra Road  
Calcutta-700009

## ABDUS SALAM (Continued from page 158)

calls 'electro-weak'. Salam believes that a further extension of the gauge principle is likely to relate the strong

interaction to the 'electro-weak'. Last to follow will be gravity when all the four forces of nature will be

shown to be mere manifestations of an all-inclusive entity.

---

## Answers and solutions

## Solutions to brain teasers

1. See Fig. 3

2. See Fig. 4

3. If the first motorist takes  $t$  hours to reach his destination, the total distance covered by him to the destination is  $36t$ . As the second motorist takes two hours more, the distance travelled by him is  $30(t+2)$ . The two distances are obviously equal i. e.  $36t = 30(t+2)$  giving  $t=10$ . So, the first motorist took 10 hours to reach the destination. Both therefore started at 9 A.M. The distance travelled by them to the destination is 360 km.

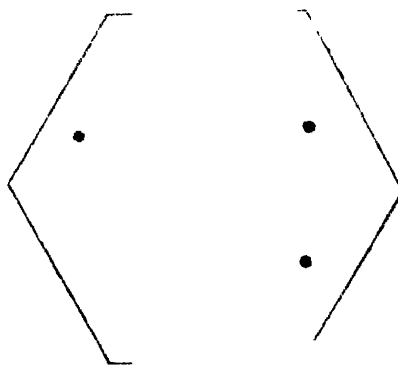


Fig. 3

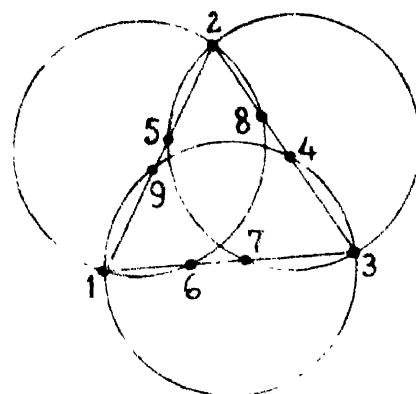


Fig. 4

## Answers to science quiz

1.(c) 2.(b) 3.(c) 4.(b) 5.(a) 6.(c) 7.(b) 8.(c) 9.(b) 10.(a)

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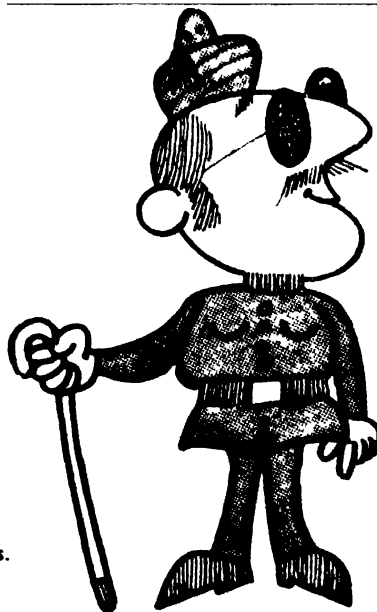
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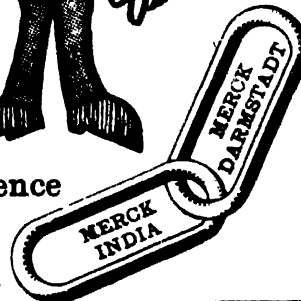


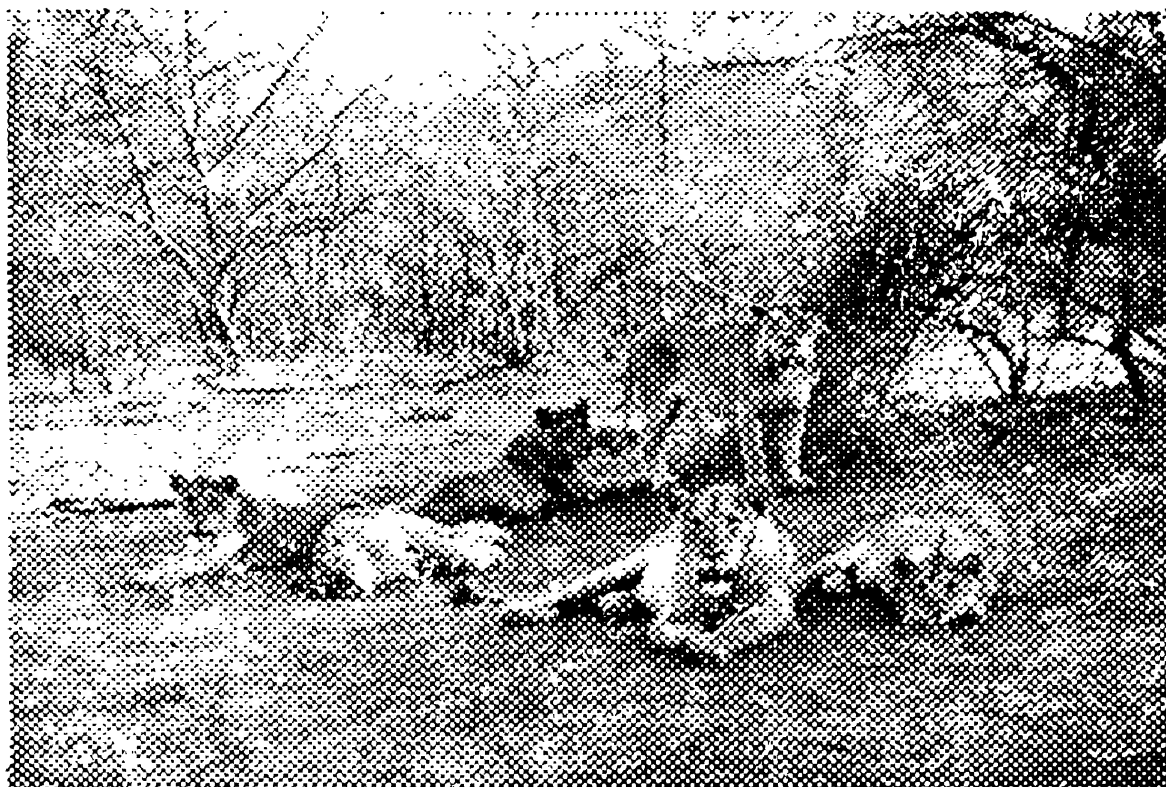
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Raghavendra Goswami  
in Medical  
**1st** Entrance  
Wardha '77



Bhupinder Bhandari  
in Medical  
**1st** Entrance  
Delhi '78



Rajiv Verma  
in Medical  
**2nd** Entrance  
Delhi '78

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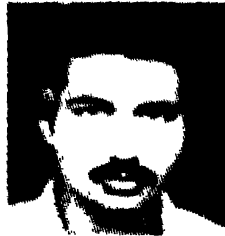


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Delhi '77



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in Medical  
Entrance  
Wardha '77



**1st** Bhupinder Bhandari  
in Medical  
Entrance  
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**2nd** Rajiv Verma  
in Medical  
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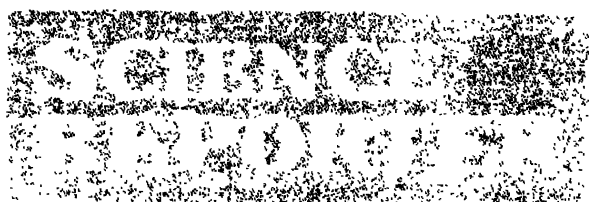
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## Vipers

Sir, The family *Viperidae* constitutes the most feared and dreadful poisonous snakes, popularly known as vipers. The general classification of family *Viperidae* is given in the well-known book by P.J. Deoras (*Snakes of India*, 3rd ed., 1978, N.B.F., New Delhi). In India, most viper species are pit bearers and therefore, known as pit vipers. In the family *Viperidae*, there are two sub-families of which sub-family *Crotalidae* (which contains a large number of genus) contains pit vipers.

Not all pit vipers are high altitude snakes; for example, the bamboo pit viper (Harnag, *Trimeresurus gramineus*) is common in regions of thick bamboo growth in peninsular India. However, the Himalayan pit viper (*Ancistrodon himalayensis*) is distributed in the hilly regions in the north and eastern parts of India.

In our article **How vipers see in the dark** (S.R., October 1979) it has been inadvertently stated that all members of the family *Viperidae* are pit bearers.

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## II

Sir, We refer to **How vipers see in the dark** by A.K. Maity and Jagdeep

One look at the evolution chart of snakes tells us that the family of vipers (*Viperidae*) has two sub-families—the *Viperinae* to which both the Russells viper (*Vipera russelli*) and the saw-scaled viper (*Echis carinatus*) belong. The pit vipers belong to the sub-family *Crotalidae* covering genera *Agkistrodon* and *Trimeresurus*. It is only in the *Crotalidae* that the pit organs are found. Both the Russells and the saw-scaled vipers do not have any pit organs. Three species are found in the *Viperidae* and sixteen among the *Crotalidae* in India.

The authors probably have brown sand boa (*Eryx johnii*) in mind while mentioning *Dumaha*. The resemblance of the head and tail in *E. johnii* is part of the species' defence mechanism, while *E. conicus* (common sand boa) depends upon its camouflage patterns to survive. *Eryx conicus*, as the name describes is a boa with a conical tail (which does not resemble its head and be mistaken for a *Dumaha*). The common sand boa is quite similar in appearance to the Indian rock python (*Python molurus*) and is known as *Chote aajar* in Hindi. The pit organs found on the Boidae are called "apical pits."

The authors have measured the sensitivity of the pit vipers' thermoreceptors as 1/300th of a degree Celsius but do not mention the range of this sensitivity. The degree of sensitivity usually varies with the distance between the object and the observer. Pit vipers are usually found on hills and mountain slopes. The mountain air gets fairly cooled in the night and helps this nocturnal sub-family locate warm-blooded prey who must maintain a constant body temperature.

I have observed pit vipers hunting their prey successfully in the hills in which their tongue was rarely used. On cooler nights (not cold wintry nights, when most

range of pit vipers increases compared to when they are hunting on less cool nights. The same pit vipers, when brought down to the warm plains, used their tongue as often as other species found on the plains. It is the difference between atomyphic and the warm-blooded animals' constant temperature which help the pit vipers sense their surroundings.

The authors hope that the discovery of the marvels of nature could *perhaps* (emphasis mine) be used for human "welfare." The only example we have of thermoreceptors being used by humans is in "welfare".

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## Nitrogen fixation

Sir, In the article **Biological fixation of nitrogen by legumes** (S.R., Sept. 1979), the information given is quite interesting but preliminary. It does not cover the recent developments in dinitrogen fixation by legumes. I would like to add some points.

Next to water, nitrogen is the most common limiting nutrient in agricultural soils. The largest proportion of this agriculturally useful nitrogen fixation is associated with the legume-rhizobium symbiosis, which is quantitatively the most important agency by which this element is incorporated into the biosphere and is the principal process for maintaining  $N_2$  fertility in agriculture. It is recognized that as an alternative to the Haber process which is capital and energy intensive, the agricultural economy can depend more extensively on biological  $N_2$  fixation, a process which derives its energy from the sun.

The role of leghaemoglobin in nitrogen fixation, i.e., by scavenging the  $O_2$  from the site of fixation is still under dispute.

Until 1975, it was thought that rhizobium could fix nitrogen only after transformation to a bacteroid in its symbiotic relationship with a legume. However, there are evidences from many laboratories, proving their *in vitro* fixation of molecular nitrogen, especially by the isolates of cowpea group, i.e., it could fix  $N_2$  in its free-living state itself, proving that they carry all the genetic information necessary for fixation.

The cross-inoculation groups on the basis of which we make commercial inoculants for different types of legumes are not given in the article.

Nitrogenase, the enzyme responsible for biological  $N_2$  fixation consists of two proteins which are irreversibly damaged by exposure to oxygen. Both proteins contain iron and comparable amounts of labile sulphur. The larger protein also contains molybdenum and is known as the MoFe protein (Component I) or molybdoferredoxin while the smaller protein is known as the Fe protein (Component II) or azoferredoxin.

The genes responsible for  $N_2$  fixation are called *nif* genes. The first successful genetical experiments on  $N_2$  fixation were reported in 1971.

The best hope for an increase in agriculturally useful biological  $N_2$  fixation lies in improving the legume-rhizobium symbiosis. Another possibility is the genetic improvement of rhizobia. This might be done by deactivating the control of nitrogenase synthesis by ammonia so that the rhizobia in symbiosis continued to fix  $N_2$  even when fertiliser N was added making optimum use of the fertiliser.

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### Deadliest animal

Sir, I read with much interest **World's deadliest animal** (S.R., Aug. 1979) by Samir Kumar Ghosh. He has mentioned that *Chironex fleckeri* is the world's deadliest animal. But recently it has been discovered that a small, colourful, winged octopus found along Australia's beaches and waterways and off the coasts of Sri Lanka and Japan may be the deadliest creature in the world. Although it rarely exceeds 10cm in length, the animal octopus maculosus carries enough toxin to kill ten men. "This octopus is more deadly than the cobra or any other creature", said Melvin Howden, a chemist at Macquarie University in Sydney, who has been studying the octopus toxin in an attempt to develop an antidote.

The octopus first came to the attention of scientists in 1969, when a 23 year old Australian soldier died within an hour after being bitten by a specimen he picked up on a Sydney beach. Its brilliant colours make this species of octopus easy to recognise. From his research so far, Howden has concluded that the octopus toxin is not a protein. No one knows what the compound is. It is water soluble.

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Ramnad District, Tamil Nadu

### Tanker accidents

Sir, In connection with the article **Oil pollution of the oceans** (S.R., April 1979) by S.P. Fondekar and Sengupta, H. Shanmukhappa in his letter 'Prevention is better than cure' (S.R., Oct. 1979) has drawn the attention to the Torrey Canyon disaster on March 18, 1967 in which 1,17,000 tons of crude oil was spilled. However, the mishap of the super tanker *Amoco Cadiz* near Portsall

on March 16, 1978 was of a greater magnitude. About  $2.574 \times 10^8$  litres of precious oil was spilled, which caused widespread devastation of the shoreline, much to the chagrin and inconvenience of the authorities and the inhabitants.

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### Explosions of the galactic nucleus

Sir, S.K. Karanjai and S.K. Barman in their interesting articles **Energy for explosion of galactic centre** (S.R., October 1979) and **Explosions at galactic centre** (S.R., January 1977) have explained various aspects of the 3 kiloparsec arm, now considered to have been formed due to an explosive activity, at the centre of our galaxy some  $2 \times 10^7$  years ago.

The authors should have also mentioned explosions in extragalactic sources. All normal galaxies, it is believed, have experienced enormous explosions. Seyfert and radio galaxies and Messier 82 provide authentic evidence in this direction.

S.K. GURTU

### Suggestion

Sir, Recently I happened to get a copy of S.R., a magazine exclusively devoted to subjects of scientific interest. I found it very useful and interesting. But for a student of any discipline other than science, it is difficult to understand most of the articles. Those who have not made a specific study of science are not supposed to understand the basic terms of science. I think it would not be wrong to say that many people are deprived of the pleasure  
(Continued on page 287)

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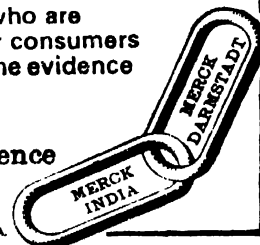
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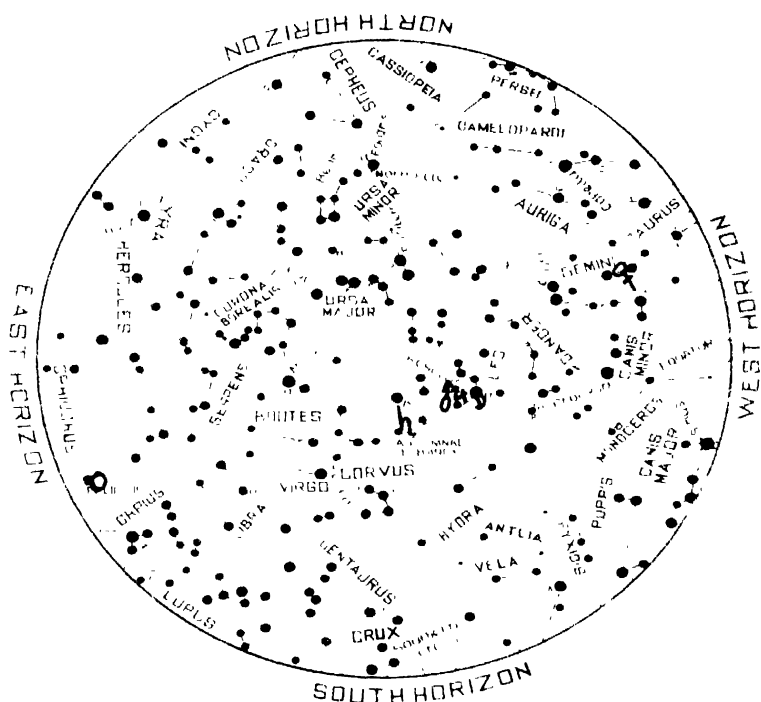
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# Planets and their positions

May 1980



**PLANETS**  
 VENUS ♀  
 JUPITER ♃  
 MARS ♂  
 SATURN ♄

**MAGNITUDES**  
 1 2 3 4 5  
 MOON  
 FIRST QUARTER 22<sup>ND</sup>  
 FULL MOON 30<sup>TH</sup>

## The moon

**N**EW moon occurs on 14th at 5.30 pm and full moon on 30th at 2.58 am I.S.T. The moon passes eight degrees south of Venus on 17th, about a degree south of Jupiter and half a degree south of Mars on 22nd, and very close to Saturn on 23rd. The lunar crescent becomes first visible

after the new moon day in the evening of 15th.

The moon is at perigee or nearest to the earth on 12th and at apogee or farthest from it on 24th.

## The planets

Mercury (Budha) is too near the sun to be visible during the first three

quarters of the month. It is in superior conjunction with the sun on 13th. Thereafter, it reappears as an evening star and sets about an hour after sunset. It moves from Aries (Mesha) to Gemini (Mithuna) through Taurus (Vrisha). Its visual magnitude varies from  $-1.3$  to  $-0.4$ .

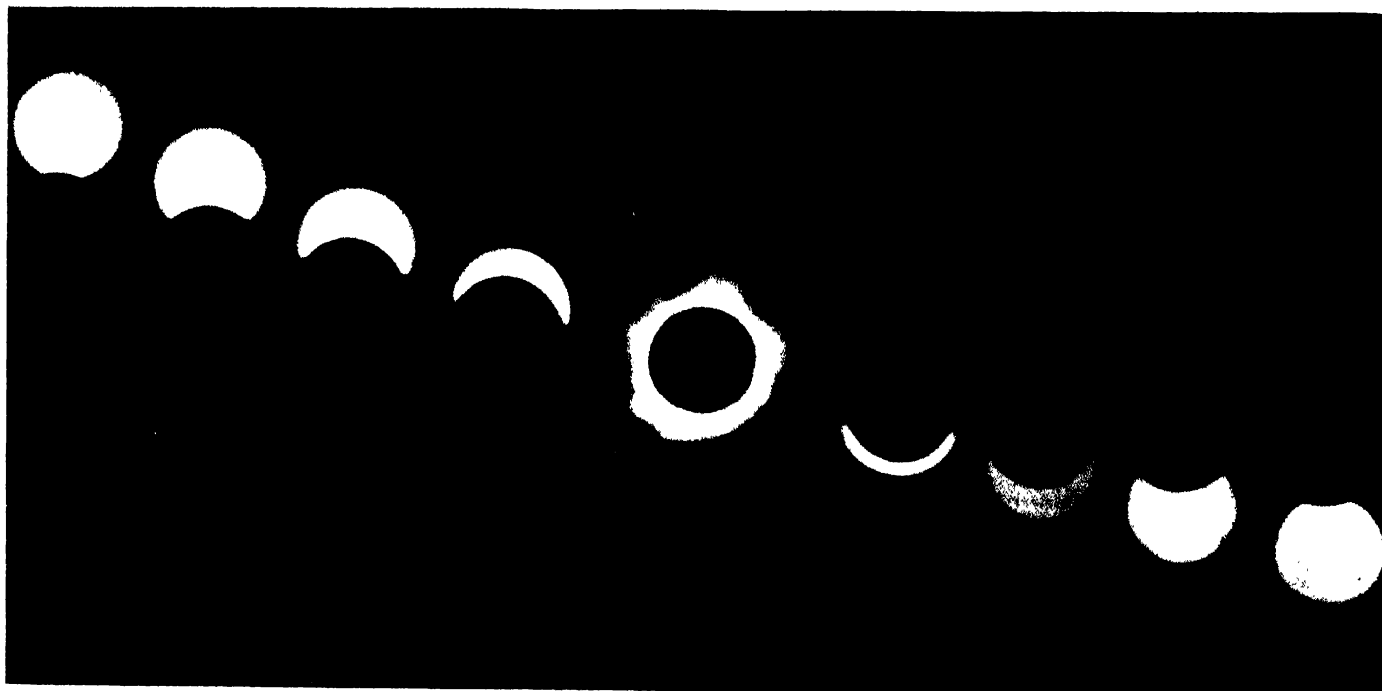
**Venus (Sukra)**, an evening star visible on the western horizon, sets about three hours after sunset during the first half of the month and about two hours after it during the second half. It is at the greatest brilliancy on 9th. It becomes retrograde on 25th. It moves from Taurus (Vrisha) to Gemini (Mithuna). Its visual magnitude is about  $-4.2$ .

**Mars (Mangala)**, visible in the evening sky, sets about one and a half hours after local midnight during the first half of the month and about it during the second half. It is in quadrature with the sun on 31st. It passes about a degree north of Jupiter on 4th. It is in Leo (Simha). Its visual magnitude varies from  $+0.4$  to  $+0.8$ .

**Jupiter (Budha)**, visible in the evening sky, sets about an hour after local midnight during the first half of the month and about it during the second half. It is in quadrature with the sun on 22nd. It is in Leo (Simha). Its visual magnitude is about  $-1.7$ .

**Saturn (Sam)**, visible in the evening sky, sets about two hours after local midnight during the first half of the month and about an hour after it during the second half. It becomes direct on 2nd. It is in Leo (Simha). Its visual magnitude is about  $+1.1$ .

(Source: Positional Astronomy Centre, India Meteorological Department, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700 053)



A photo-montage showing the eclipse from beginning to end

# THE TOTAL

*Article and photographs*

**BIMAN BASU**

**I**T was mid-afternoon on Saturday, 16th February, 1980. We stood on the terrace of our hotel in Puri facing the partially eclipsed sun—now only a thin crescent—in the western sky. In a few more minutes the moon—slowly creeping up from below—would cover up the solar disc heralding the beginning of “totality”. We waited expectantly. There was a patch of cloud near the sun; but it soon melted away. Then we saw it coming—the dark shadow of the moon—from the distant southwest horizon over the sea. In a moment it was upon us. Suddenly it was darkness all round. It was so dark I had to use a flashlight to set the camera shutter. It looked as if some magical hand had switched off the daylight. We could feel a sudden drop in temperature.

not there. In its place hung a black disc with a faint bluish pink halo of the solar corona around it. At many points along the rim of the dark disc could be seen minute red flaming tongues of solar prominences. It was an unforgettable sight.

Higher up in the now darkened inky-blue sky, we could see the planets Mercury and Venus shining brightly. Most of the brighter stars—Capella, Deneb, Aldebaran, Fomalhaut and the beautiful Pleiades cluster—could be seen clearly. The sky on the northeastern horizon glowed with a soft orange colour, as if dawn was near.

But the darkness was short-lived; it lasted only a little more than two minutes. Soon, small dots of light—called Bailey’s Beads—appeared on the lower edge of the dark sun. In the

flash as the sun’s photosphere came into view from behind the moon’s disc, forming a celestial “diamond ring”. The darkness vanished as suddenly as it had come. The solar crescent grew fuller and brighter and it was day again.

What we had just witnessed was a total eclipse of the sun—one of the grandest spectacles of nature. Such eclipses are not quite uncommon (they occur once in about every 18 months or so), but this particular one was of special interest to us in India. It was the first total solar eclipse of this century to be visible over the Indian mainland. The last time it was on January 22, 1898. Another significant fact was that in India, its “path of totality” lay over populated and easily accessible places. This proved to be of great advantage to

from all over the world to study the eclipse. They could get all the necessary facilities to set up their instruments locally.

While for most amateurs like me the eclipse offered a rare opportunity to see the 'once-in-a-lifetime' event, for astronomers and astrophysicists it was another chance to peep into the secrets of the sun, which they do by studying the solar chromosphere and corona during totality. Thousands of scientists from India and countries as far apart as the United States and Japan utilized the opportunity to make intensive studies of the sun's corona and chromosphere which are visible only during a total eclipse. Experiments were carried out at 15 'eclipse camps' set up along the 1,500 km path of totality (which stretched from Gokarana in Karnataka on the west coast to Konark in Orissa on the east coast) and about 100 other centres spread over the country. Clear skies and fine weather all along the path of totality helped the scientists gather a wealth of data.

While processing of all the data would take months, one

of the first findings to come from these observations was that the sun's corona was extraordinarily bright on the day of the eclipse. This made the 'false' night at totality less dark than expected. The photographs also revealed that the corona was compact and evenly spread around the solar disc as was expected during this year of maximum solar activity. At the time of the eclipse a large sunspot could be seen near the right limb of the sun even with the naked eye (of course, when seen through special filters). (Two days before the day of the eclipse as many as three sunspots were seen.)

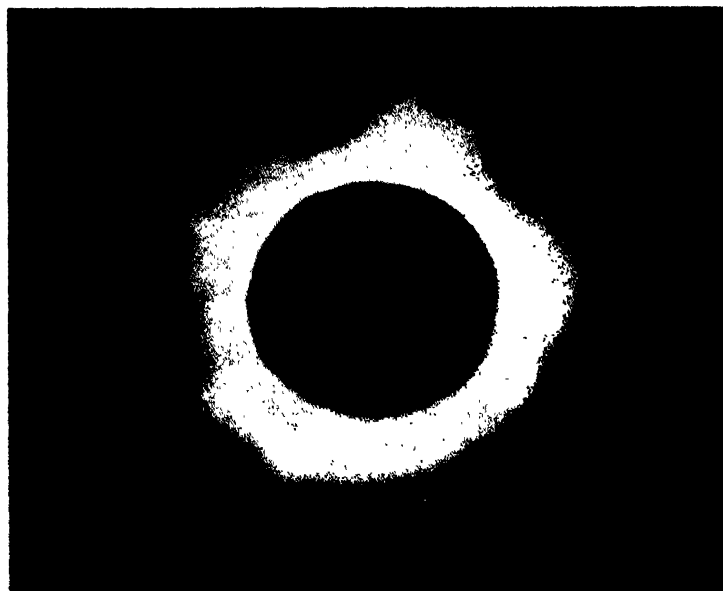
One of the most interesting experiments conducted during the totality concerned search for possible 'rings' around the sun like the ones around Saturn, Jupiter and Uranus. Scientists of the Indian Space Research Organisation took infrared 'scans' of the eclipsed sun to find that out.

Rockets carrying scientific payloads were fired from three centres—Thumba (Kerala), Sriharikota

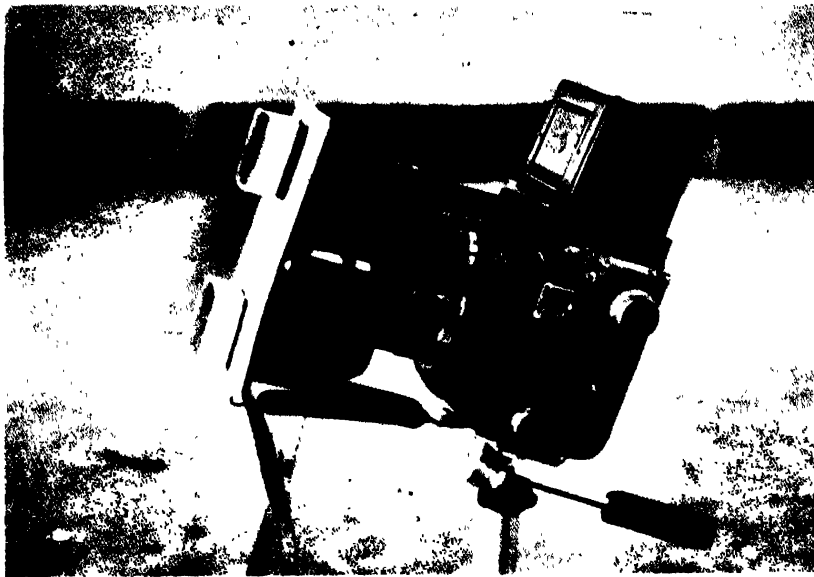


Celestial "diamond ring" marking end of totality

(Andhra Pradesh) and Balasore (Orissa)—to study changes in the earth's environment during totality. While the launchings from Thumba and Sriharikota were successful, one of the important scientific experiments to measure positive ion density in the upper atmosphere failed because the second Rohini-200 rocket launched from Balasore



The solar corona. The intensity of the corona is not uniform all through. It decreases sharply outward from the solar surface. These photographs taken with different shutter speeds (*Left*-1/60 sec, *right*-1 sec) show the extent of the different regions



**The camera set-up**

**Y**OU needn't have expensive telephoto lenses to photograph an eclipse. All the photographs in this article were taken with the improvised set-up shown above. A 8x30 prismatic binocular was hooked up with a twin-lens reflex camera in place of a telephoto lens. The exposure was calculated by the formula:

$$A \times C/B = f$$

where A and B are the magnification and objective lens diameter res-

pectively of the binocular and C the focal length of the camera lens. The f-number for the above set-up came to about 22.

The filters (the dark square box-like objects in the front) were made by exposing to daylight and developing a 400 ASA black-and-white film and mounting cut pieces of it between two glass layers. The filter was used for all the photographs (except those of the corona) and the exposure in each case was the same (1/125th sec). The corona photographs were taken without filter.

lost contact with the ground station 30 seconds after launch.

As physicists and astronomers were busy studying the eclipsed sun and its effects on the earth's atmosphere, teams of biologists looked for unusual behaviour of plants and animals (and even humans) during the totality. As anyone who had seen it once would know, the swift onset of darkness at totality can be terrifying to the uninitiated. If animals and birds behave erratically, it is simply because they get terrified

and confused. Some plants and flowers which close their leaves or petals at night are often fooled by the false night at totality. But these are simple instinctive or physiological reactions and there is nothing surprising about it. The important point is that unusual behaviour of plants and animals are seen only along the path of totality and rarely at places where only a partial eclipse is seen.

Contrary to popular belief there were no "unusually high" tides during the eclipse. At Puri, the sea

was in fact calmer than usual. The eclipse also did not trigger any earthquake as predicted by many.

The unfortunate thing was that millions missed their lifetime's chance to see the spectacle simply because of false propaganda about evil effects of the eclipse. People were so scared that they simply shut themselves indoors during the eclipse lest "rays" of the eclipsed sun cause harm to them! Metropolitan cities like Delhi, Calcutta, Bombay and Madras looked like ghost cities with shops and offices closed, streets deserted and even public transport off the road.

The fear was unfounded, for there is no scientific basis to believe that the eclipsed sun is more dangerous than the uneclipsed one. The simple fact is that it is unsafe to look at the sun without adequate eye protection, be it at the time of an eclipse or not. But it is absurd to think that going out in the open during an eclipse can cause any harm (except of course if one is bent upon looking at the sun with the naked eye). With proper filters (and they are so simple to make) anyone could follow the progress of the eclipse without any danger as most of us, in fact, did.

#### **A reader's experience**

Sir, I left Bombay by the Bombay-Madras Mail on the night of 15th February, with the specific intention of witnessing the total eclipse of the sun enroute. According to my calculations, I could witness this at the Mantralayam station, provided the train ran on time and this part was a great gamble. It is also to be noted that no other train in India would have passed the belt of totality during the period the eclipse was total. I picked out a few young men in my compartment who were also of a scientific bent of mind, though they too did not know that we would be witnessing the total eclipse en-

*(Continued on page 236)*

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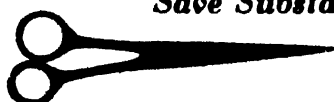
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**S**TELLAR dynamics, like relativity, is essentially a twentieth century product. A notable figure who had a considerable influence on developments in both these fields of investigation was Arthur Eddington. In 1914, he wrote one of the first important monographs entitled *Stellar Movements and the Structure of the Universe* on stellar dynamics. Basically, the aim of that time was to make some inferences about the physical structure of stellar systems from the latest measurements of the proper motions and radial velocities of bright stars. Though regarded as somewhat mundane nowadays, data of this kind were then relative-

stars whose relative motion was such as to cause an elongated distribution in velocity space. On the other hand, Schwarzschild explained the same elongation by the mathematically elegant and so-called ellipsoidal hypothesis. He suggested that dispersing forces acted on galactic motions in such a way as to cause stars to deviate from the mean motion more on the average in one direction than in the directions at right angles. The fact that strong enough dispersing forces could not be identified was not considered to detract from the theory, since at that time, star ages were not known. The forces were supposed to be

ment of Schwarzschild's hypothesis. By this time, as it happens, Eddington had moved away from the field of stellar dynamics and it would perhaps be unfair to credit him with too great an influence in the matter. Nevertheless, it is certain that the ellipsoidal hypothesis very soon triumphed.

The events that led to this were the very nearly simultaneous discoveries of the sun's great distance from the galactic centre and its rotation around this centre at about 250 kilometres per second. These discoveries were closely followed by a theory of "steady state" gravitational orbits in star systems which

# IS RELATIVITY RIGHT?

**Even Einstein was at first not completely sure of his theory of relativity as is evident from his frequent uses of the word 'heuristic' to describe it**

S. V. M. CLUBE

vely new and amongst the most accurate available to astrophysicists. They captured the attention of the most able investigators of the period, and conclusions reached were all beautifully summarised in Eddington's book. It was well before astronomers knew about galactic rotation or even the general direction of the galactic centre, and so, easily the most striking effect that had emerged at that stage was the non-spherical distribution of nearby stars in velocity space. This was explained in principle in two different ways. On the one hand, Kapteyn had proposed the so-called two stream hypothesis in which he supposed the solar neighbourhood was filled by two intermingling but non-interacting swarms of

gravitational however, and therefore not particular as to the physical constitution of the stars involved.

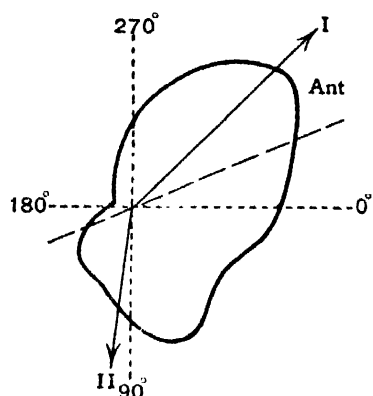
It was generally recognized that the choice between these dynamical theories might be settled by checking whether there was any correlation between the physical attributes of individual stars and their positions in velocity space. Unfortunately this was not a simple problem to resolve since neither suitable observations nor a theory of stellar evolution were then available. Readers of his 1914 monograph will appreciate that Eddington took great care to sit on the fence in respect of this controversy. Ten to twenty years later however, he was, as far as I can tell, condoning the establish-

provided an explanation as to why they should be dispersed more in one direction than the other. It was very much to the credit of the theory that the greatest velocity dispersion should have been in the direction of the galactic centre and this was in satisfactory accord with the observations.

But while all this was going on, there were other astronomers out of the limelight, even in the 1930's and 1940's still searching to see whether Kapteyn's streams had different physical properties. By 1935, it was beginning to be clear that there really was a difference. Looking back with the advantages of hindsight, we can see such a discovery had all the qualities of a skeleton



**Fig. 1.** Normal contrast print of the core of the large elliptical galaxy and powerful radio source, Centaurus A. This shows very clearly the dust lanes and disc structure that one normally associates with typical spiral galaxies. The motions therein indicate rotation and probably expansion that is associated with the large-scale binary structure at radio wavelengths not visible on this print (Copyright Royal Observatory, Edinburgh)



v. Region VII., centre R.A. 20<sup>h</sup>, Dec. +50°

Fig. 2. This diagram taken from Eddington's monograph on stellar dynamics illustrates a typical distribution of proper motion position angles in a certain region of the sky for stars within a few hundred parsecs of the sun. The scalar size of the radius vector in each direction is simply proportional to the number of stars moving that way. Although the distribution has the elongated shape that characterises an ellipsoidal distribution, it also shows signs of bi-lobed structure characteristic of the two stream hypothesis. Modern observations confirm that the latter property is physically real.

in the cupboard, but as it turned out, the bones were not rattled loudly enough by those in the know to stop radio astronomers of the 1950's and later theoreticians taking over the ellipsoidal hypothesis and all its consequences as fact of life. To cut a long story short, it is now obvious that Stream 1 and Stream 2 differ in their ages. (Stellar ages were simply not known in 1920, but we now know that most of the stars in the solar neighbourhood belong to Stream 1 and are relatively young, while the older ones belong to Stream 2.) In general, an age below or above a few  $10^6$  years, segregates the stars into Streams 1 and 2 respectively. Whatever the motion of Stream 1, the elongated distribution in velocity space has to be interpreted as evidence that Stream 2 is moving relative to Stream 1 towards the galactic centre.

Unfortunately, this discovery goes a long way towards weakening the theory that attributes the same phenomenon solely to galactic rotation. Thus, by the theory, the older stars are expected to have very well mixed orbits and one would therefore expect to see as many of these stars going in towards the centre of the galaxy as there are going out. This means the motion of Stream 2 in particular is neither in nor out with respect to the galactic centre. We can thus really understand the observations only if most of the young stars in the solar neighbourhood are at this moment away from the centre at the rather high speed of around 40 kilometres per second. This is another way of saying that most of the constituents of nearby spiral arms, that is gas, dust and young stars, are part of a temporarily expanding system. Simple calculations show there must then be radical changes in the spiral structure in something like  $10^8$  years, only one per cent or so of the total galactic lifetime. Taken at its face value then, the structure is not in a steady state and one of the planks supporting the modern theory of galaxies is severely undermined. Now, it has to be admitted that this expansion is not yet generally accepted by today's astronomers - extreme caution is necessary when such radical proposals are on the cards - but the variety of up-to-date evidence, radio and optical, providing support for the thesis is so extensive that it has to be considered a very real possibility.

I mention all this simply to point out that Eddington, who had written a definitive book on the subject, had it very much within his grasp to temper the enthusiasm with which astronomers have gone chasing after galaxies as if their structure was unquestionably always dynamically steady. Like the curious incident of the dog in the night that did not bark, it seems quite remarkable that Eddington did

not comment on what was going on. One could wonder whether the Jeans-van Maanen fiasco (see R. Berendzen & R. Hart, *J. Hist. Astr.*, 4, 73, 1973) had any lasting influence on the matter. During the 1920's and 1930's Jeans supported measurements made by van Maanen that implied spiral arms were rotating extremely rapidly - periodicities as short as  $10^6$  years seemed to be indicated. As it turned out, the measurements were quite erroneous and suggestions of rapid evolution of spiral structure became slightly disreputable. Did astronomers like Eddington over-react by giving tacit approval to steady state schemes for galaxies? One could conclude that this is the reason why later astronomers have gone on and on developing steady state models of galaxies, even though at times, they have become quite desperate in their hunt for the density waves that Lindblad - very early on - isolated under the circumstances as the only conceivable explanation of spiral structures.

Perhaps on the other hand, Eddington was simply preoccupied with other things. Apart from his achievements in stellar dynamics and the internal constitution of stars, he also distinguished himself in the field of relativity. As has been well brought out in the centenary year of Einstein's birth, Eddington played a quite crucial role in the advancement of Einstein's theories, especially by bringing it to the attention of English-speaking people. He first got to know the general theory of relativity in exceptional war-time conditions through a contact with de Sitter in Holland, and then, barely before the world had settled to more peaceful times, was instrumental in furthering experiments to confirm one of the predictions of Einstein's theory. By the early 1920's he had written an important monograph - *Mathematical Theory of Relativity* - on this subject as well.

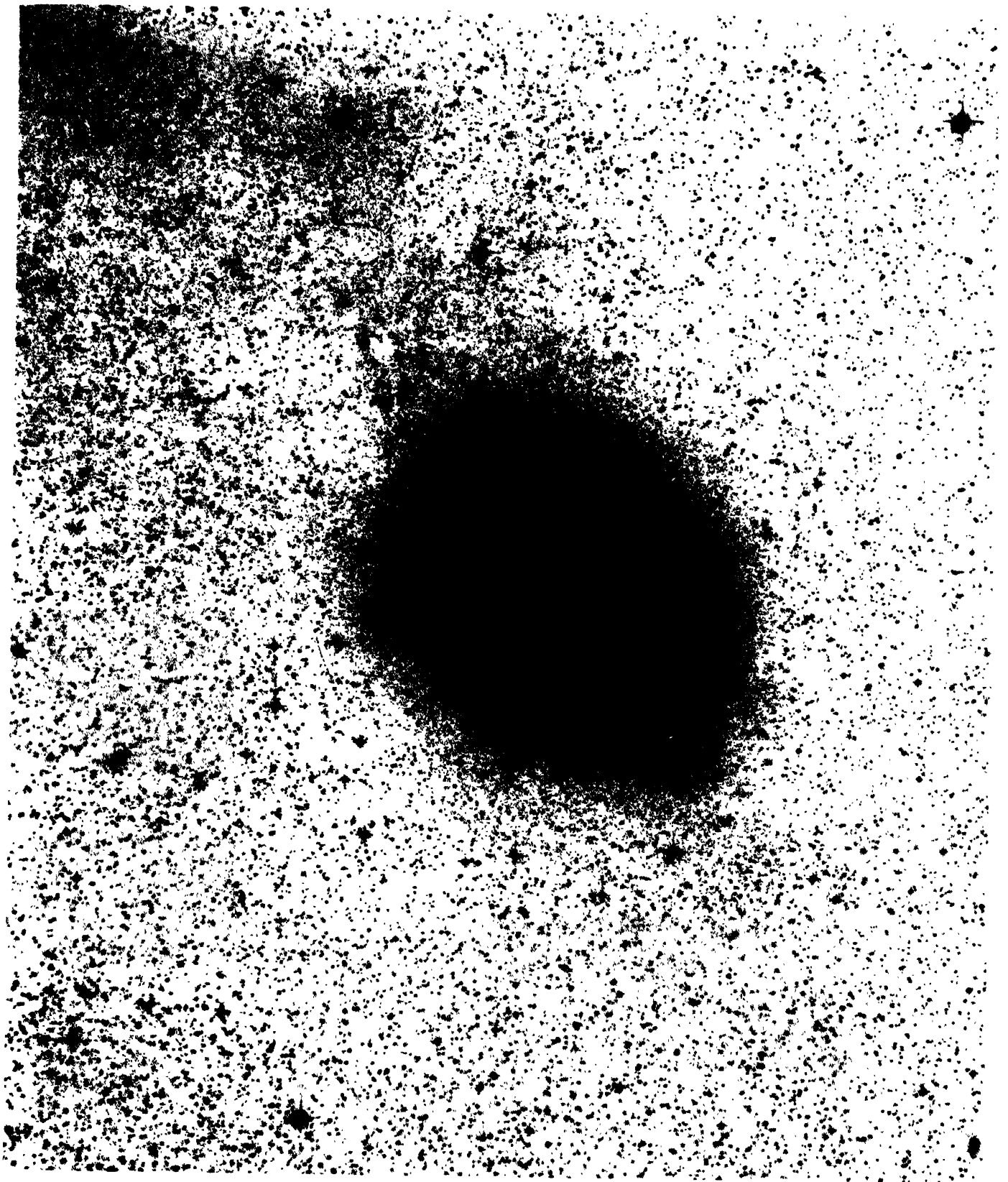


Fig. 3. High contrast print of Centaurus A with the same scale and orientation as of Fig. 1. This shows the parent elliptical galaxy. Unlike the normal oblate spheroidal structure of galaxies, this is prolate. According to the theory discussed here, both the prolate structure and disc are the results of a recent hypermassive nucleus breaking up (*Copyright: Royal Observatory, Edinburgh*)

It is difficult now to assess the impact of all this, but we have the assurance of people of the time that it was considerable. This may seem a little strange since the modern physicist is brought up to see 1905 as the crucial date in the life of relativity. This was certainly when Einstein published his first paper on special relativity, but it is perhaps not properly appreciated by most people today that the theory was not at first accepted. Indeed it was generally rejected by all but a few. The genius of Einstein was of course quickly recognized—he clearly had a knack for taking mathematical formulations of fundamental physical phenomena and devising radical and simple new derivations of these formulations, often requiring basic new concepts that nobody could gainsay. In the case of relativity, Einstein introduced operational definitions of space and time. That even Einstein himself was not at first completely sure about his theory is evident enough in his frequent use of the word 'heuristic' to describe it. That he was fundamentally offended by operationalism as a foundation for physical science is amply demonstrated by his lifetime battle with quantum theory. But like all good scientists, he was content to let Nature and experiment be the final arbiter. As Einstein himself emphasized, his original announcement of relativity did not recognise the Michelson-Morley experiment, and there can be very little doubt that he eventually took this to be the crucial demonstration of the validity of his theory. When he first began his research however, the phenomenon many physicists were seeking to explain was the fact of Lorentz invariance. This had first emerged when Maxwell's wave equation seemed to be invariant (at least, to the precision of the observations) to any presumed motion of the observer in the aether.

As is well-known, Einstein

explained all this by invoking the principle of relativity, but the same phenomena were also explained within the context of Newtonian theory by Lorentz who argued for certain physical effects as matter moved through the material aether. Physicists, almost to a man, favoured Lorentz's theory and regarded Einstein's as mathematically neat but physically unimportant. Followers of Lorentz, unlike Einstein, however, gave very little successful thought to the problem of explaining gravity within the framework of Lorentz's theory. It was in these circumstances therefore that Eddington emerged with powerful support for Einstein's 1916 development of his 1905 theory to explain some subtle gravitational effects which had not previously been understood. The outcome was traumatic since physicists found themselves obliged to concede the beauty of Einstein's theory, but at the same time, logically forced to abandon Lorentz's theory and all that it stood for. Above all, where the world had been previously filled with a material aether which had been a kind of *raison d'être* behind field theories for well over a century, they now found it physically empty. Moreover, where space and time formerly had intuitive meaning, one was now obliged to accept operational definitions. All this was quite definitely anathema to physicists, so Eddington was at the forefront of a revolution.

It is now of course simply a brief incident in history when Einstein and Eddington between them caused astronomy to take over the leadership of modern physics. Within a decade, mathematical physicists had themselves absorbed the new ideas and brought them back within the realm of laboratory physics. As is well-known, Dirac applied Einstein's ideas, special relativity in particular, to the quantum theory of atoms. The well-known result was paired solu-

tions of positive and negative energy which were quickly identified as the electron and the then recently discovered positron respectively. Dirac then sought a physical understanding of these positive and mysterious negative solutions which, though exotic, has developed into our modern picture involving a fundamental vacuum state of zero mass.

All these ideas are obviously designed to be consistent with the aether of Einstein which physicists had at first found so appalling, but which has now settled into the mainstream of modern physical thought. However, the present day surge of activity amongst studies of astronomical bodies in states of extreme gravitational collapse is now bringing previously untestable aspects of Einstein's gravitational theory into the front line of developments: once again, astronomy stands poised to take the lead even as high energy physicists delve deeper into the nucleus, seeking ever more exotic applications of the zero mass vacuum to their understanding of the structure of matter. It would be tantalizing in the extreme, to say the least, if these new confrontations between fact and theory were in the end to tell us that Eddington was responsible for misleading us—that he had by his silence, not only directed astronomers away from Kapteyn, but by his determined advocacy of general relativity, also directed physicists away from Lorentz and the existence of a real material vacuum.

Such a prospect is much more in sight than is generally given credence at the moment. To see that this is so, however, it is necessary to wear tinted spectacles to avoid being dazzled by the Big Bang. Modern astronomy presents us with a microwave background that Lorentz, if he were alive, would quite plausibly and no doubt confidently attribute to his material vacuum. Its measured velocity would quite naturally reflect

that previously elusive concept—our absolute motion. Modern astronomers are also very busy hunting for missing matter which Lorentz would be quite happy to locate (sometimes invisibly) in this material vacuum. According to this picture, the aether particles would have a kind of dual character; inside, a very massive component which is both invisible and frictionless, yet providing a pressure that does most of the work against the external pressure of the surrounding medium, and outside, a very slight shell, so lacking in inertia as to have no measurable effects in dynamical experiments and so weakly energetic as to be barely visible and only then at a very low absolute temperature. Recognizable material particles on the other hand have a quite different energy partition; a much less massive invisible component surrounded by a visible shell containing a large amount of energy. The invisible components contain the so-called potential energy, and all states of matter would be in dynamical equilibrium with the surrounding aether.

Gravitational (and other) fields would of course represent different energy states of the material vacuum, and it would be very clearly understood that gravitational collapse, engineered as it is by aethereal forces, would transfer vast amounts of energy from the vacuum to visible matter giving rise to very massive high red-shift “quasars” in the centre of galaxies as well as very massive stars in the final stages of their evolution. These collapsed states would, like particles and anti-particles bound together in the vacuum, very probably have binary structure which is now very commonly observed in double radio sources and other paired systems. The excess mass in quasars would of course be the visible “missing matter”. To be consistent with the observations, the hypermassive state would have to

be recognized as a temporary phase in the evolution of galactic nuclei. Each time it is formed, its huge but short-lived gravitational field will cause violent instability in the parent galaxy while the nucleus bifurcates and gives rise to spiral arms.

One of the age-old problems with mechanisms requiring ejection of spiral arms from galactic nuclei is the fact that the velocity has to be far in excess of the normal escape velocity. Since it now takes place in the presence of a temporary hypermassive state, the arms remain bound. These spiral arms would each time expand away from the nucleus of the galaxy and probably later, fall back towards the centre. With this understanding of modern observations, it would be impossible to treat galaxies, at least in the short term, as steady state systems—they would be subject to really violent upheavals. Two peculiarly twentieth century theories, namely stellar dynamics and relativity, have thus conspired so far to tell us our galaxy is a very gentle affair which might just have once had a quasar in its centre a very long time ago. If Eddington was wrong on both counts, stellar dynamics and relativity, our galaxy could on the contrary be a violently active affair with hypermassive quasars popping on and off every hundred million years or so.

The reader who has arrived at this point without tripping over may now start to wonder where he was tricked! How can some new interpretation of astronomical phenomena possibly be telling us that Einstein is wrong? Surely everyone knows relativity is right? The truth of the matter of course is that we don't know for certain, though most physicists are brought up believing we do. Indeed the manner of their training is often more akin to indoctrination with a faith than it is to development of an open mind. Since there are many text books that implicitly or explicitly confuse the

issue by telling us that Lorentz's theory and Einstein's theory are mathematically equivalent, and very few physicists actually read Lorentz's original papers to discover the contrary is the case, it is not surprising this sorry state of affairs has come about.

In actual fact, Lorentz's theory, firmly grounded in Newtonian physics and acknowledging the existence of a real material vacuum was specially constructed to explain both the Michelson-Morley experiment and the well-established fact that nature appears to be Lorentz invariant. As Lorentz maintained all his life, the theory is quite distinct from relativity; or as he put it relativity is Einstein's theory, not mine. Obviously what is required is an experiment to distinguish between the theories. Unfortunately, the critical experiment to measure the “one-way” velocity of light, the only direct way of validating Lorentz's theory rather than Einstein's theory, has not yet been performed.

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Science humour is generally of a mild type and is not designed to produce a guffaw or loud laughter. It operates at a somewhat sophisticated level and because of the technical nature of the subject, the humour at times may not be apparent to the layman. William B. Jensen has brought to light two early examples of this type. First is a poem by John Cargill Brough in which he expresses his despair at being confounded by conflicting chemical theories of the time. A stanza in Brough's poem reads:

The second example consists of a set of satirical drawings on a system of graphic formulae proposed by Guthrie. He suggested that chemical elements should

## B. C. SHARMA

be graphically represented by geometric objects having a number of sides equal to the valencies of the elements, e.g., a point for hydrogen, a line for oxygen, a triangle for nitrogen, etc. Reacting to this suggestion, an anonymous contributor produced a set of drawings in which the molecule  $N_2O_5$  looks like a cone of ice-cream and the molecule  $NH_4HSO_4$  resembles a human face (Fig. 1).

He was so pure a theorist that he never entered a laboratory, if perchance he ever did so some expensive piece of apparatus would shatter spontaneously.

A more recent article on the theme of a theorist versus an experimentalist is *Social Currents in Weak Interactions*. It starts "...while anomalous experimental data seem frequently to be pushed without creating much of a stew, the experimental claims in this instance were taken seriously by those working in weak interactions." Finally this delightful take off on the professional jealousies and groupism among scientists concludes that, in general, theorists fall into four categories. The first group is of pure theorists who believe that "since the experiments did not agree with theory, the experiments were probably wrong". The second group of theorists consists of "statesmen" who try to be diplomatic in approach. The third group of theorists "seemed to prefer that the current theory be valid, but in case it was not, they wanted to be in on the next theoretical movement, preferably leading the parade" The fourth group is of course required to make up the audience in any conference for the first three groups. The experimentalists of course reciprocate the sentiments expressed towards them by theorists. They "... take some pleasure in deflating the edifice constructed by theorists. To discover a violation of  $\Delta S = \Delta Q$  rule would be a joy few experimentalists could pass up".

E. Schreiber and O.L. Anderson have contributed an article on 'Science on Properties and Compositions of Lunar Materials : Earth Analogies.' Written in the serious manner of scientific papers, the article is complete with tabular data which are interpreted to indicate that the curves for lunar rocks fit

the cheeses. A casual reader who does not glance at the references may be almost half-way through before he realises that his leg is being pulled. A similar tongue-in-cheek account of 'The Stability of Bicycle' is provided by D.E.M. Jones in *Physics Today*. It caught the fancy of many readers who sent in their learned responses in the form of letters to the editor. Many weighty issues raised by readers were replied to by the author in an equally serious tone.

A satire on the peer review system and the editorial discretion is entitled *A Rational Scale of Critical Editorial Evaluation*. In this article, V.D. Frechetle and R.H. Condit introduce the International Scale of Critical Comment or Terse Index of Scientific Censure (TISC—TISC). The Publishability Figure of Merit ( $M_p$ ) of any communication is given by an exact equation

$$M_p = - \frac{F}{p(R - U)} - [A/s + E - N] \cdot$$

$$\Sigma \frac{\text{TISC} - \text{TISC}}{n} + E$$

where apart from factors like frequency of publication of the periodical (F), its number of pages (p) and average advertisement received per issue (A), etc., E is an arbitrary parameter (assignable by the editor) which varies from  $+10^{22}$  to  $-10^{22}$ . TISC—TISC is mostly negative and "TISC—TISC coefficient of astonishment is the natural logarithm of the astonishment experienced by a reviewer upon confrontation with a particular statement from a prospective author."

Apart from serious science journals which occasionally publish science humour, there are journals devoted exclusively to science humour like *The Journal of Irreproduci-*

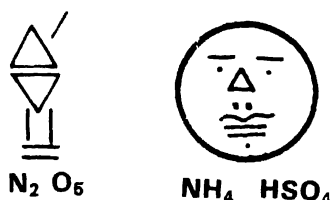


Fig. 1

ficant Research, the *Worm Runner's Digest*, etc. The *Worm Runner's Digest* was started by an active research worker, James V. McConnell as a one time "personal little joke on the scientific establishment." However, it caught the fancy of many other active scientists who poured in contributions and McConnell was forced to turn it into a regular publication. McConnell tells the story of the birth of his journal in an article, *Confessions of a Scientific Humourist*. The *Journal of Irreproducible Research* was started by Prof. Alexander Kohn of the Hebrew University, Israel. He describes how the journal was born as a result of some jokes exchanged with friends on the subject of mysterious disappearance of glassware from chemical laboratories. The problem was tackled in a paper entitled *The Kinetics of Inactivation of Glassware*, which became the first issue of *JIR*. Soon the *Journal* started receiving contributions from all over the world. A Society for Basic Irreproducible Research was formed with "Dr. X. Perry Mental" as the Executive Secretary. Some of the papers published in the *JIR* are: *Theoretical Zipperdynamics*, *The Chemistry of Copulation VI: An Interpretation in Terms of the Activated State Theory of Chemical Kinetics*, *How to be a Project Leader*, *Researchmanship*, *Boardmanship and Mathmanship*. The last named paper shows how to put even the simplest of things in mathematical terms so as to infuse proper scientific gravity. For example,  $1+1=2$  elegantly as

$$\ln \left\{ \lim_{z \rightarrow \infty} (1 + 1/z)^2 \right\} + (\sin^2 x + \cos^2 x)$$

Another paper announced the discovery of a new contraceptive, NO-acetol, a ring compound with —NO— in every position. That the use of serious tone and "appropriate" scientific language can be fool many, scientists included, is shown by the reception accorded to a similar article on armpitin, another contraceptive (again having NO groups) published in the *Journal of Canadian Medical Association*. It was seriously reviewed in the *Annual Reviews of Pharmacology* and some pharmaceutical firms even tried to buy the patent.

A category of items having some bearing on the 'real' sociology of science includes the New Laws of Science. Some of these are:-

*Parkinson's Third Law* The progress of science varies inversely with the number of journals published.

*Cummidge's Law* The amount of expertise varies in inverse proportion to the number of statements understood by the general public.

*Mater's Law* If facts do not conform to theory, they must be disposed of.

*Bruce's Law* You can publish almost anything provided you try sufficiently enough.

*Pardee's Law* There is an inverse relationship between the uniqueness of an observation and the number of investigators who report it simultaneously.

*Law of the Constant Compensatory Evidence* Weakness in experimental support can be made good with extensive citation.

Some quotable quotes are: "The only way for a new theory to become accepted is for the adherents of the old theories to die", "A new idea is the most quickly acting antigen known to science", "A stitch in time would confuse Einstein", "Even if one were a descendent of a long of hair



not secure the individual against baldness" and "Though scientific work is based on accurate records, the maintenance of adequate records does not in itself constitute research."

The literature of science humour has progressed from occasional items in regular science journals to the book form. Examples of this last category are, *Psychology in the Wry*, *Stress Analysis of a Strapless Evening Gown*, *Expertland*, *The Worm Re-Turns* and *The Scientist Speculates*. These books are collections of essays, news items and jokes on topics ranging from psychology to biology. Though all the topics are not scientific in nature, they have been contributed by scientists. Some parody the scientific method of investigation while others are flights of fancy based on half-baked ideas. In the book form, science humour has a much better chance of being

noticed by the common man and also perhaps of achieving a sort of permanence.

Science humour produced so far has been an effort of scientists for the consumption of scientific community. In the process, however, the veil of secrecy surrounding science has been lifted a bit. Even the common man can see that science is an activity carried out by human beings who are as much flawed or unflawed, as much susceptible to baser and finer human emotions and instincts as any other group of human beings. This humanization of science should be welcomed since science is not the concern of scientists alone.

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## THE TOTAL ECLIPSE (Continued from page 226)

route, and we carefully chalked out our plans. Our train was first running late by fifteen minutes, but soon this was made up and we reached Raichur the next afternoon fifteen minutes before time. The eclipse started while we were strolling on the Raichur platform. A large number of tourists who had come to witness the total eclipse at Raichur were thronging the platform with their dark glasses and cameras.

The train left Raichur on time and we saw the sun was getting more and more obscured. We could see all around the horizon a sort of darkness creeping in and flocks of birds were flying in a confused manner. The air was getting colder and evidently a steep fall in temperature was taking

place. The sky was clear and there was not a speck of cloud.

The train reached Mantralayam station in time, after crossing the Tungabhadra river, where we could see scores of persons taking their holy dip. By this time the eclipse was fast approaching totality. All the passengers were down on the platform. The moon's shadow-cone suddenly swept over us and the eclipse became total. The wonderful 'corona' burst into view as a pearly white light surrounding the eclipsed sun, but I did not see the Baily's Beads nor any prominence. The corona too did not appear to be large as it should at the time of sunspot maximum. The darkness at this time was comparable to that just an hour after sunset. We could see the planets Venus and

Mercury, but no star was discernible.

The moment totality was over, the beautiful 'diamond ring' flashed into view for a few seconds, though this was not seen in the beginning. The sun began to reappear. One of my friends had a glimpse of the fast moving 'Shadow hands' on the platform for a few seconds just at this moment. The duration of totality was two minutes and twentyfive seconds. Immediately after this the whistle was given and we all rushed back into the train and the train moved on from the platform.

C.K. ANANTHABURAMANIAM

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[Sh. Ananthasubramaniam's article  
Total eclipses of the sun appeared in  
S.R., December 1978]

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**T**HROMBOSIS is a pathological phenomenon caused by the accumulation of blood clots or aggregates of blood platelets—thrombi—inside the blood vessels, whence blood ceases to circulate beneficially. It was believed, at one time, that thrombosis originated from the inflammation of the inner layer of the blood vessels due to the deposition of fatty materials—lipids—from the flowing blood. Although physical changes in the vessel wall could be a factor causing thrombosis, it was later recognised, that

The deposition of a mass consisting of platelets, leukocytes and fibrin and its continuous growth to occlude the lumen of a specific vascular segment can be linked to abnormalities—(i) of the blood vessels, (ii) of the circulating blood or, (iii) of the blood-flow.

Although it has been suggested that factors such as high blood pressure, serum lipid level or cigarette-smoking are linked with thrombotic arterial disease, and also with coronary disease, our knowledge about cerebral and peripheral

(ii) cerebral thrombosis, and (iii) venous thrombosis.

*Coronary thrombosis.* It is mainly a heart disease with two subgroups. First, myocardial infarction in which patients characteristically have chest pain, abnormalities of ECG and changes in serum-enzyme level. Second, angina pectoris in which patients are suddenly dropped to death or first experience chest pain and then die.

*Cerebral thrombosis.* It is a vascular disease of the central nervous system and is less

SWAPAN  
CHATTOPADHYAY

B. B. NATH

the stasis in blood-flow due to changes in blood, was the causative factor. The formation of “fibrin” from the plasma and the entrapped cellular fractions of the blood like platelets, leukocytes (white blood cells) and erythrocytes (red corpuscles) inside this fibril mesh-work constituting the thrombus, are responsible for the arrest of blood flow without causing any external bleeding.

Thrombosis—not an uncommon vascular disease—has been considered by some to be even more hazardous than certain malignant diseases like cancer. In fact, mortality from this disease far exceeds that of the latter. Although the basic nature of the sequence of events leading to the formation of thrombus inside blood vessels has yet to be elucidated, the development of our knowledge of the mechanism of blood coagulation has contributed much to the synthesis and production of several drugs for the prevention or cure of this disease.

**Although the pathology and cure of thrombosis—coronary, cerebral and venous thrombosis—still remain a challenge to the clinical science, our knowledge of blood coagulation mechanism has helped the preparation and synthesis of several drugs for combating this disease**

arterial thrombosis is far from complete. As the blood flow rates in the artery and in the vein are not similar, the nature of the thrombotic problem in them is different. In arteries, the thrombus formed is resistant to blood flow, and produces infarction, whereas in veins it leads to their disruption and embolisation into the lungs.

#### Types of thrombosis

Thrombosis may be classified as : (i) coronary thrombosis,

well-studied than coronary thrombosis. It occurs due to bleeding in brain or due to abnormalities in walls of cerebral arteries.

*Venous thrombosis.* It occurs in veins of legs and pelvis, with the formation of thrombus. The thrombus formed may enter into blood vessels of lung causing pulmonary thrombosis.

#### Structure of thrombi

Thrombi are constituted by blood-platelets, leukocytes and

# THROMBOSIS AND ITS CURE

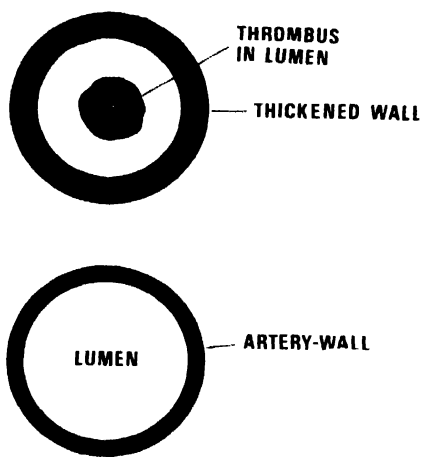


Fig. 1

fibrin-clot. The structure and action of thrombus in arteries and in veins are different. Structurally too they differ. In arterial thrombus, the 'white-head' mass is constituted mainly by platelets, leucocytes and fibrin, whereas in venous thrombus, the 'red-tail', composed of the fibrin clot and red cell trapped in it, is the major component. The difference in structure may be attributed to the difference in rate of blood-flow in arteries and in veins. However, the difference is not absolute since intermediate structures are also observed.

### Causes

At the end of the nineteenth century the reason for coronary thrombosis was thought to be the narrowing of the lumen of blood vessel due to the thickening of its wall by the formation of lipid-containing material on the intima of the arteries. Initially, these lesions are formed as yellow streaks, linearly along the intima of arteries which in later stage develop an increased accumulation of phospholipids, lipoproteins and cholesterol. Then these lesions will have a grey or pearly white fibrous form containing cholesterol crystals and gradually proliferate into the arterial lumen

causing partial or complete blocking of the blood flow. Later, it has been seen that the accumulation of lipid materials is not solely responsible for thrombosis but the increase in serum-lipid level of blood is also a major factor which enhances the blood clotting within the arterial lumen through thrombus (Fig. 1). Thus the initiation of thrombosis and the culmination of the disease is not only due to pathological changes in the artery wall, as was thought to be, but due mainly to the changes in the blood-clotting mechanism.

### Thrombus formation

For the formation of fibrin network the blood protein, fibrinogen, is split by the proteolytic enzyme, thrombin, produced during the process of clotting. During the reactions with enzymes and other clotting factors like calcium ions and phospholipids, prothrombin discards half of its molecular weight and is transformed into thrombin. Two of the generally

accepted mechanisms are given in Figs. 2 and 3.

The mechanism of blood clotting inside the blood vessels involves twelve factors (factor I to XIII, excluding factor VI which does not exist) which are present in normal circulating blood. Deficiency of any of these factors causes various diseases with bleeding symptoms like haemophilia, Christmas disease, etc. In the normal blood which is not deficient in any of the clotting factors, the mechanism involves essentially the activation of enzymes which trigger the subsequent activation processes and a chain of reactions which proceed sequentially.

It is nowadays believed that the activated factor  $\bar{X}$ —termed by some workers as factor  $\lambda_a$ , thrombokinase, autoprothrombin-C or activated Stuart-Prower factor—is the primary enzyme which reacts with prothrombin of the circulating blood in presence of accelerators like factor V, calcium ions and phospholipids to produce thrombin.

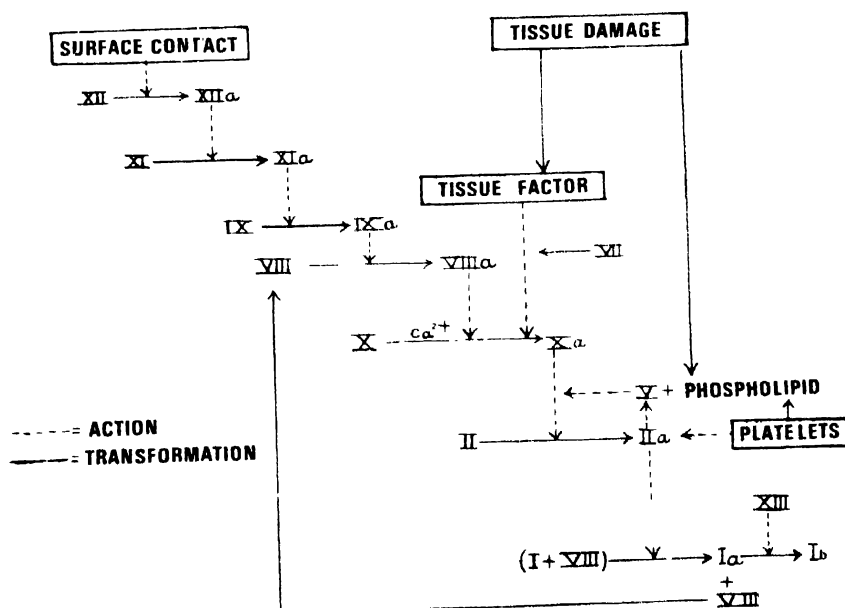


Fig. 2. I-Fibrinogen; Ia-Fibrin; Ib-Stabilised fibrin; II-Prothrombin; V-Accelerator globulin; VII-Proconvertin; VIII-Antihaemophilic factor; IX-Christmas factor; X-Stuart-Prower factor; XI-Plasma thromboplastin antecedent (PTA); XII-Hageman factor; XIII-Fibrin stabilising factor

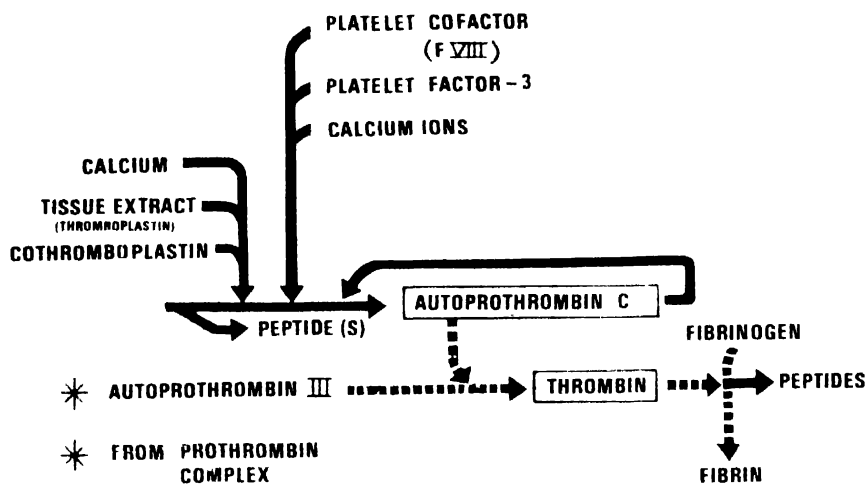


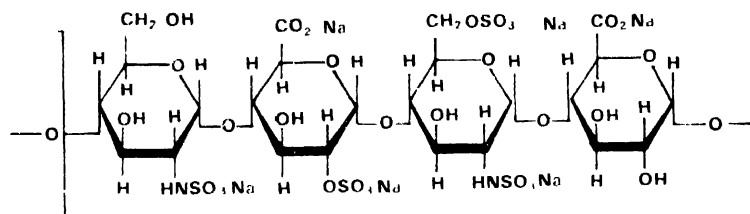
Fig. 1

Factor Xa is produced by the interventions of the activated forms of the factors XII, XI, IX and VIII through various enzymatic reactions in circulating blood (intrinsic mechanism) and by tissue-thromboplastin and factor VII during injury (extrinsic mechanism) as shown in Fig. 2.

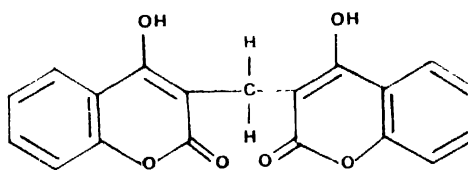
On the onset of the chain reaction, Hageman factor (factor XII) is, at first, activated to its active form, XIIa, through surface contact. It has been observed that, if a sample of blood is taken in a wax or silicone-coated tube, it takes a prolonged clotting time, as a smooth surface is less active in activating the Hageman factor. Factor XIIa, which is an enzyme, then activates plasma thromboplastin antecedent (PTA), factor XI, to its activated form which in its turn activates the Christmas factor (factor IX). The latter's activated form, IXa, then acts on anti-haemophilic factor (factor VIII). The activated form of factor VIII (VIIIa) then reacts with factor X (Stuart-Prower factor) to produce the active form, Xa. At this stage thrombin plays an important role; it not only acts on fibrinogen of blood to produce fibrin but also acts on platelets to produce phospholipids. Once a little amount of

enzyme, thrombin, is formed it readily acts on fibrinogen of blood to produce fibrin monomer which polymerises to insoluble cross-linked fibrin polymer in presence of factor XIII (fibrin stabilising factor) and calcium ion.

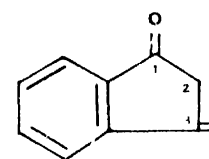
The dissolution of the stabilised fibrin clot, fibrinolysis, may occur by the action of the proteolytic enzyme, plasmin or fibrinolysin which is the active product derived from plasminogen or profibrinolysin present in blood. This fibrinolytic process goes on normally inside body to protect the flowing blood from the possible accumulation of blood clots which may be formed inside the blood vessel even under



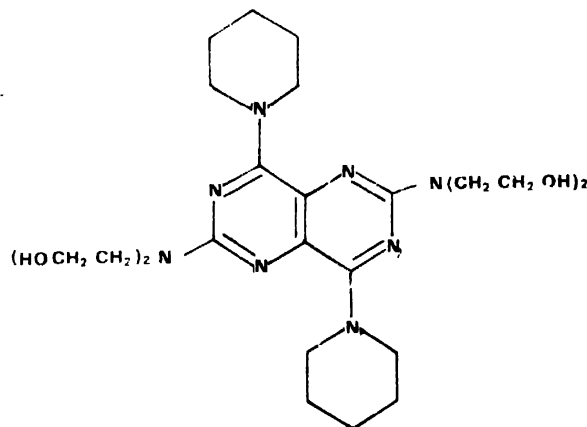
HEPARIN



DICOUMAROL



1,3 INDANDIONE



DIPYRIDAMOLE

non-pathological condition. The mechanism of blood clotting process *in vivo*, i.e., inside the blood vessels (intrinsic mechanism) is slightly different from that caused by any injury. Some of the factors described above may not be involved in extrinsic mechanism where enzymes from the tissue juice (thromboplastin) and factor VII produce the necessary shunt (Fig. 2).

Some research workers in this field believe that so many factors may not be involved in clotting process and some of the clotting factors, in fact, are the degraded products of the parent proteins like prothrombin. Seegers' group in the U.S.A. is the major exponent of this theory and a sketch of the mechanism of blood clotting advanced by them has been presented in Fig. 3.

### Therapy

Depending upon their mode of actions, the drugs used against thrombosis may be classified as :

(1) Drugs acting against platelet adhesion or aggregation, (2) Drugs causing fibrin removal, and (3) Drugs preventing fibrin formation.

Amongst the drugs which have been synthesized to act against

platelet aggregation, acetyl salicylic acid (Aspirin) or coronary vasodilator like dipyridamole (Fig. 4) have been found to be effective. The drug, urokinase, which is an enzyme purified from urine, is found to be an effective fibrinolytic agent causing the conversion of plasminogen to plasmin that lyses the fibrin clot. Recently, snake venoms like Malayan pit viper venom, in their purified form, have been studied and used to decompose fibrin after the formation of thrombus. Anticoagulant drugs which could prevent thrombus formation or suppress formation of some of the clotting agents by blocking the chain reaction at any stage are being extensively used for the prevention of thrombosis. Amongst these drugs, heparin (Fig. 4) which has been prepared from tissue-extracts having inhibitory effects on thrombin-fibrinogen reaction, is usually administered intravenously.

Out of the drugs which can depress certain clotting factors, dicoumarol and indandione groups of drugs (Fig. 4) are important. These anticoagulant drugs, usually used orally, are effective in controlling the production of prothrombin in liver and responsible for maintaining a low level of blood clotting agents.

Although our knowledge of the

cause of thrombus formation is far from complete and the study of the mechanism of the clotting process is still in progress, yet with knowledge gathered so far it has been possible to prepare various drugs, which can prevent the onset or progress of this disease.

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## SCIENCE IN INDUSTRY (Continued from page 283)

The aqueous solution of the acid is used as a cosmetic rinse for hair to make hair lustrous. In the preparation of bleaching lotions, citric acid is an important additive.

### Other industrial uses

Based on the acidic property and the sequestering action with various metal ions, the citric acid has many industrial applications. For rust and scale removal, particu-

larly from iron, the acid is an useful reagent. All general metal cleaners invariably contain some amount of citric acid. In electroplating of copper, the acid is a good additive for it increases the electrode efficiency and helps for a smooth lustrous surface. Addition of small amount of citric acid also helps effective electropickling of copper and its alloys. As an additive, citric acid is used in many industrial applications. To mention a few, it is used in printing industry,

in inks, ink indicators, floor cement and silvering compounds, etc.

Considering its manifold uses and different industrial applications, the demand for citric acid is increasing day by day. Its potential will further improve if it is available cheaply in the world market.

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*Gene synthesis and gene transferring  
Are the techniques of genetic engineering,  
Which confer on us some pains,*

*Some tears, some cheers and some gains.  
It takes one thorn out of chest of man,  
And shapes another thorn to take the  
test of man,*

*So guidelines had to be issued to genetic engineers,  
Not to engineer recombinants, which  
increase fears.*

**G**ENETIC engineering deals with artificial modification of the genetic constitution of a living cell by introduction of foreign DNA through experimental techniques. Research on genetic engineering is centered on *in vitro* joining of DNA fragments of different origins by the mediation of some highly specific enzymes to form 'recombinant' DNA which is then introduced into appropriate hosts. This way immense possibilities are raised to bring about new gene combinations not occurring in nature. The science of genetic engineering is

still in its infancy. Even then, its enormous potential impacts, both social and commercial, are evident.

Deoxyribonucleic acid (DNA) is the genetic material of all living organisms (Fig. 1). It has a long thread-like molecular structure made up of many deoxyribonucleotides (deoxyribonucleotide is a compound which consists of a nitrogenous base bonded to the sugar, deoxyribose which in turn is bound to a phosphate group) and is mostly in the form of a double helix. The two strands of DNA have deoxyribose sugar mole-

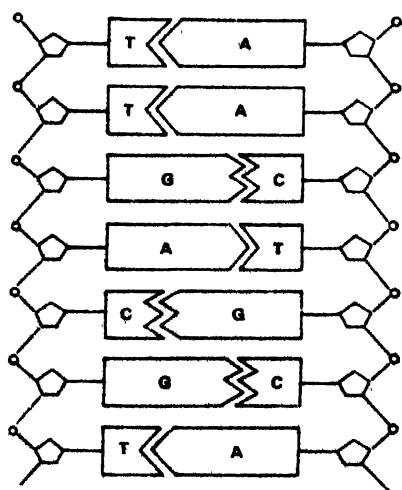
lar sequence of nitrogenous bases. The two strands of DNA can be separated by heating and when cooled again, pairing of complementary strands takes place (annealing). In this way single strands of DNA (single chain of polynucleotides) from different sources can pair if there are segments with complementary base pairs.

#### Tools of genetic engineering

The various 'biological tools' in use to bring about genetic manipulations include enzymes, passenger DNA and vehicle DNA. Foreign

**Genetic engineering raises the possibility of bringing about new gene combinations not found in nature, and better understanding of hereditary diseases and their cure**

D. K. SANDHU      G. S. VIRDI



cules joined through phosphate residues to form the backbone. On the inner side of sugars in both strands are bonded nitrogenous bases which are pyrimidines—cytosine (C) and thymine (T) and purines—adenine (A) and guanine (G). Adenine is complementary to thymine and pairs with it, while guanine is complementary to cytosine and pairs with it. The specificity of DNA lies in the particu-

Fig. 1. Deoxyribonucleic acid (DNA)  
○—deoxyribose sugar, O—phosphate group, C—cytosine, G—guanine, A—adenine, T—thymine

DNA which is passively transferred from one cell to another cell or organism is known as passenger DNA while the DNA which acts as the carrier is known as vehicle DNA. There are specific enzymes without which it would not have been possible to perform these experiments. Most important of them are DNA cleaving enzymes like exonucleases, endonucleases and restriction endonucleases (Fig. 2). Exonucleases can digest the base pairs on the 5' or 3' ends of single stranded DNA or at single strand nicks or gaps in duplex (double stranded) DNA. Endonucleases

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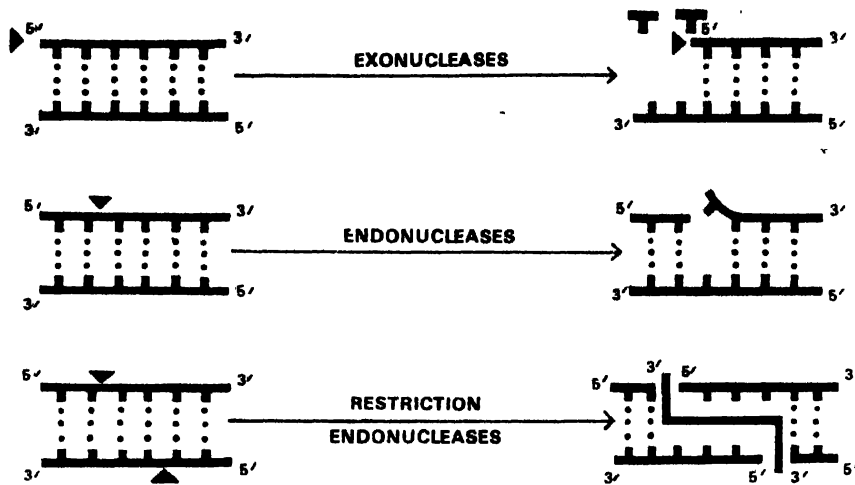


Fig. 2. DNA cleaving enzymes

can cleave duplex DNA at any point except the ends, but their action involves only one strand of the duplex. Restriction endonucleases act by making breaks only within nucleotide sequences which exhibit two-fold symmetry around a given point (e.g.,  $\begin{smallmatrix} \text{CCA} & \times & \text{TGG} \\ \text{GGT} & \times & \text{ACC} \end{smallmatrix}$  since the same sequence (running in opposite directions) is found on both strands, such enzymes can cleave duplex DNA (e.g., passenger and vehicle DNA) in such a way as to

produce complementary 'sticky ends' (complementary single-stranded free ends projecting from otherwise double-stranded DNA) which then act as a splint for joining of two DNA fragments. There are other enzymes which help in various ways in the completion of the whole process. Some of them are reverse transcriptases (used to synthesize complementary DNA strands using RNA as a template), DNA polymerases (help in synthesis of complementary DNA strand on a DNA template),

$T_4$  ligases (help in sealing or joining the nicks in DNA fragments), and alkaline phosphatases (digest 5' phosphate groups from free ends of linearised vehicle DNA to prevent recircularization).

### Vehicle DNA

Two types of DNA have been employed as vehicles, viz., plasmid DNA and bacteriophage DNA (Fig. 3). Plasmids are extrachromosomal DNAs that occur in closed circular forms in bacteria. They can exist and multiply independently of the organism's own genome. Each plasmid

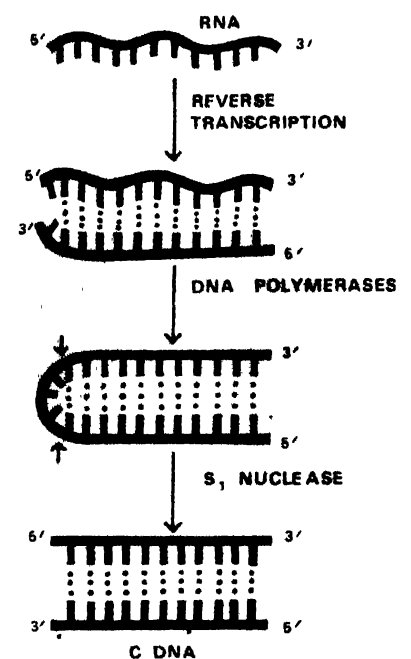
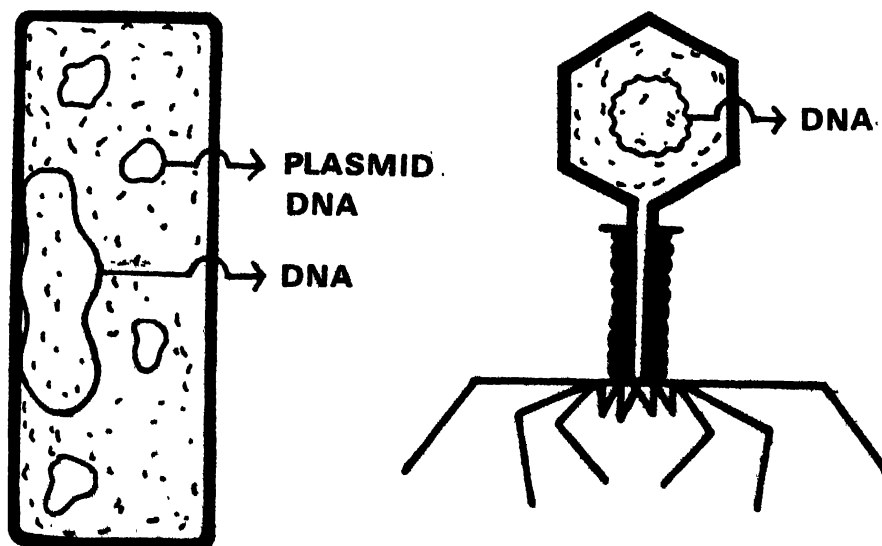


Fig. 4. Synthesis of complementary DNA



carries its own replicator region and retains its characters after recombining with foreign DNA. It may carry additional information such as antibiotic resistance factor. Not being a part of the original genome, plasmid DNA can be isolated and transferred easily due to its small size.

Bacteriophages are viruses which live on bacteria. Their DNA can also be used as vehicle DNA, provided



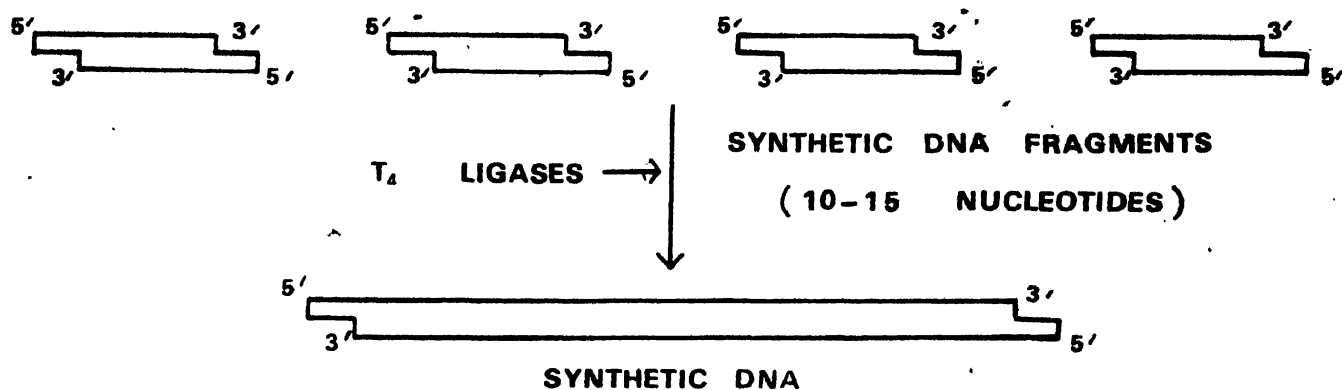


Fig. 5. Synthesis of DNA by purely chemical means

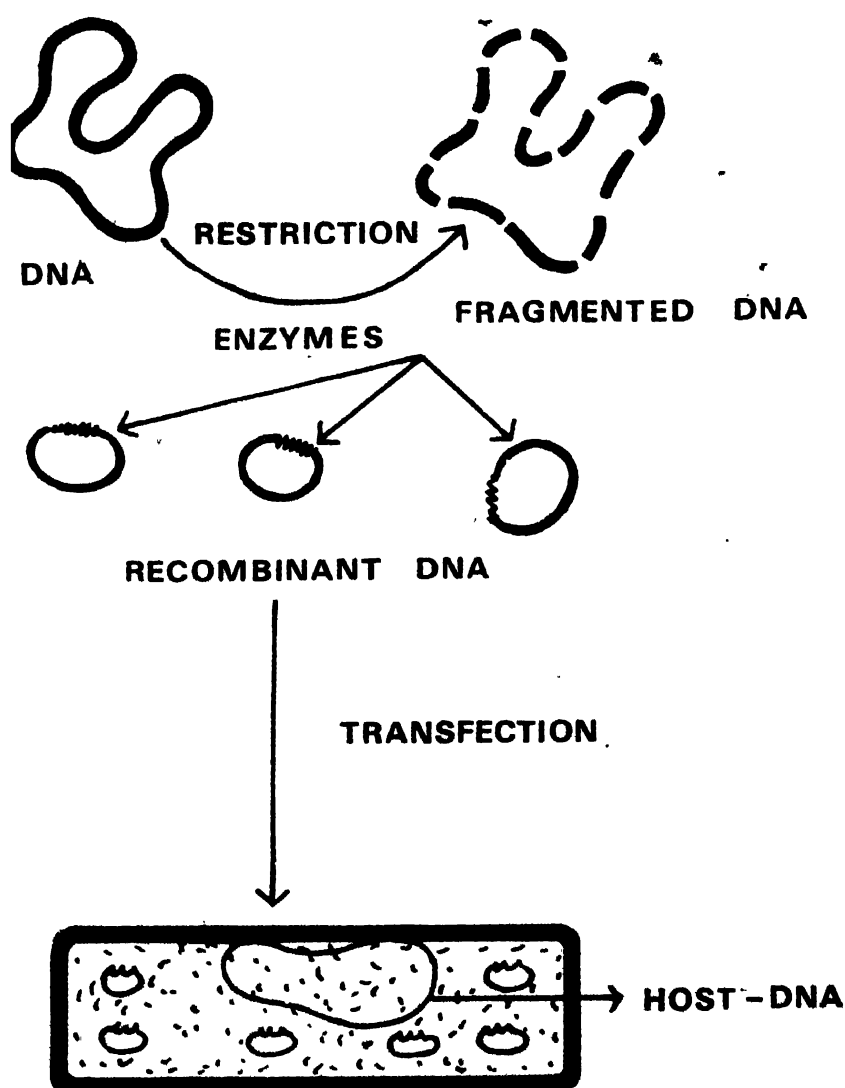


Fig. 6. 'Shotgun' experiment for producing random DNA.

it is suitably modified. In case of mammals, SV 40 (Simian virus) DNA is used as a vehicle to transfer genes.

#### Passenger DNA

DNAs employed as passenger include (i) Complementary DNA (cDNA) (ii) Synthetic DNA, and (iii) Random DNA. Complementary DNA is synthesized on a RNA template with the help of reverse transcriptase. The DNA-RNA complex is then subjected to alkaline digestion to isolate single-stranded DNA. A complementary DNA strand is synthesized on this single-stranded DNA by DNA polymerases (Fig. 4). The cDNA so produced is specific for a gene and can be linked to a vehicle DNA for transfer.

The credit for producing the first synthetic DNA goes to Hargobind Khorana and his colleagues who synthesized purely by chemical means a DNA coding for tyrosine transfer DNA. They synthesized short segments with sticky ends which were later joined to complete the full sequence of the gene (Fig. 5). This synthetic gene has been found to be functional.

The above two methods produce DNA fragments which are specific for a function. If it is not possible to use the cDNA or synthetic DNA, a 'shotgun' experiment is carried out to produ

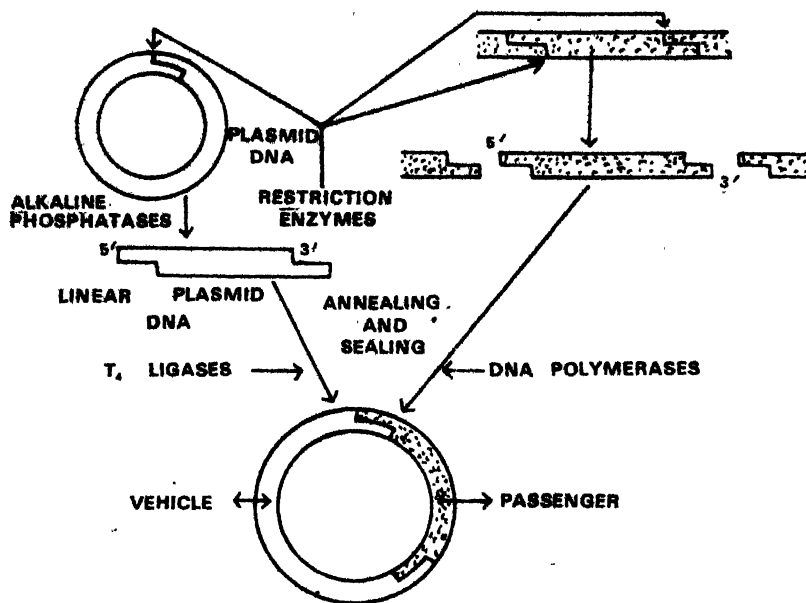


Fig. 7. Integration of vehicle DNA with passenger DNA by means of restriction enzymes

and sealing with ligase form recombinant DNA (Fig. 7).

(ii) *By extending tails.* This method is used when either one or both the DNAs lack restriction sites or may have different restriction sites. The circular DNA of a plasmid is linearised, or DNA from a bacteriophage is fragmented to act as vehicle DNA. In the presence of either of the four deoxyribonucleotide phosphates (precursors of DNA), dATP (deoxyadenosinetriphosphate), dTTP (deoxythymidine triphosphate), dCTP

In this procedure the whole DNA of a given organism is exposed to restriction endonucleases in order to obtain many DNA fragments carrying different coding sequences. Each fragment is recombined with a suitable vehicle DNA and recombinants of different nature are produced which can be transferred to a host and tested for specific gene product (Fig. 6).

#### Integration of passenger DNA to vehicle DNA

DNA to be used as passenger or vehicle is extracted from the cell by lysing it with the help of enzymes, e.g., lysozyme in the case of bacteria. The DNA is separated from other cell contents by ultracentrifugation and purified. The integration of passenger and vehicle DNA can be brought about in any of the three ways.

(i) *By the use of restriction enzymes.* DNAs of different origin are cleaved by the same restriction enzyme to produce complementary sticky ends which after annealing

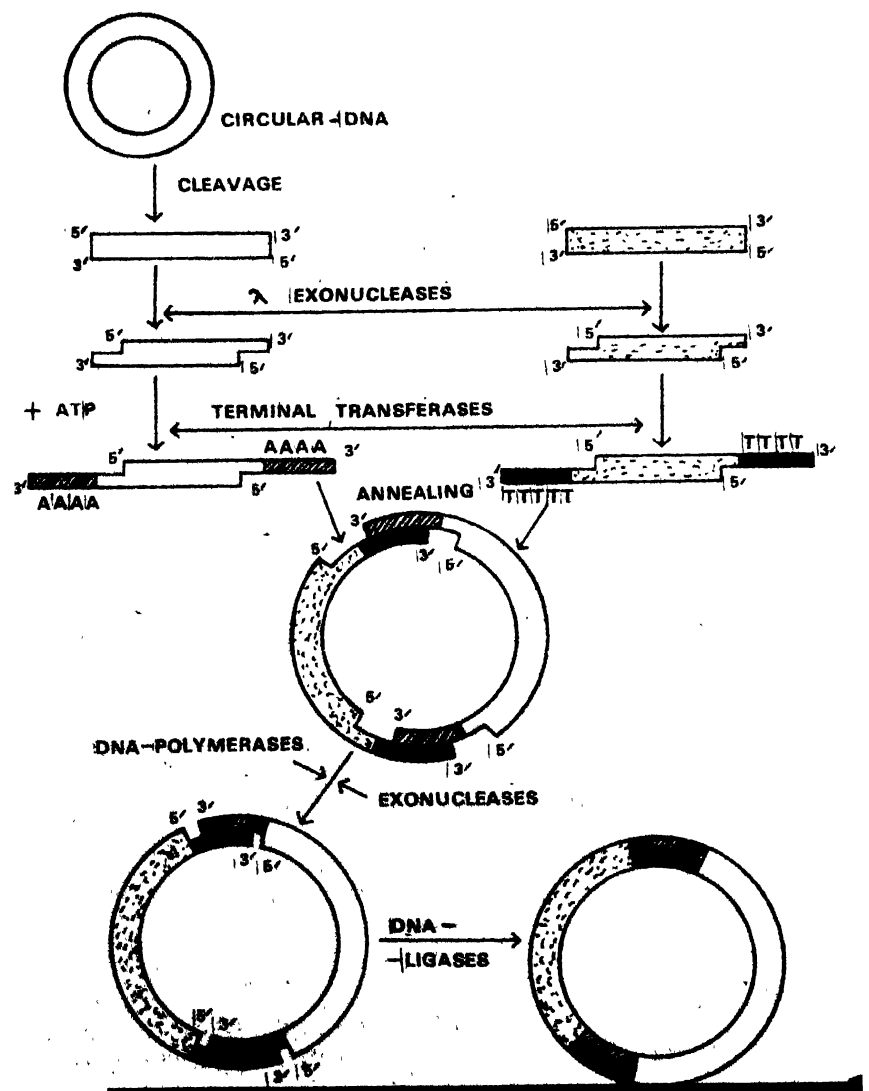


Fig. 8. Integration of vehicle and passenger DNA by the extending tails method

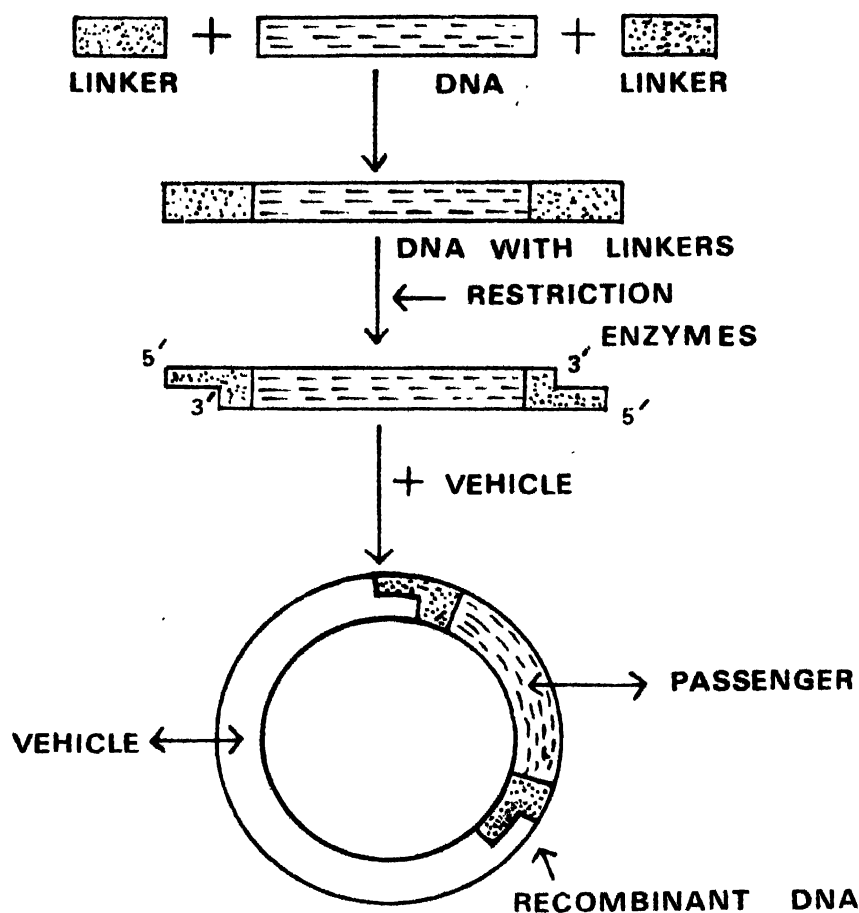


Fig. 9. Production of restriction sites on DNA by linkers

(deoxycytidine triphosphate) or dGTP (deoxyguanosine triphosphate), single stranded free ends (tails) containing poly A (AAA), poly T (TTT...), poly C (CCC...) or poly G (GGG...) are extended at 3' ends of duplex DNA by DNA polymerase (Fig. 8). The passenger DNA is also treated in the same way and the tails extended are complementary to vehicle DNA. After annealing the two DNAs, the nicks are joined by ligase.

(iii) *By use of linkers.* When a foreign DNA has no restriction sites or there is no chance of getting similar sticky ends, a known sequence of 8-10 synthetic base pairs is attached to blunt ended DNA (duplex DNA with no tails) with the help of  $T_4$  ligases. These 'linkers' (sequences) provide the restriction enzyme sites

similar to those of vehicle DNA (Fig 9). Different linkers have different restriction sites. The sticky ends carrying passenger and vehicle DNA are joined to form recombinant DNA.

For introduction or transfer of foreign DNA, use is made of the well-known process of bacterial transformation. The bacteria which act as hosts are treated with  $\text{CaCl}_2$  or an enzyme such as lysozyme to make the cells more permeable. When recombinant DNA is added to the growth medium in which such bacteria are growing, it is taken up by the bacteria along with nutrients (Fig 10). So far the rat insulin gene, rabbit globin, sheep somatostatin and *Klebsiella pneumoniae* 'nif' genes have been transferred successfully to *E. coli*, but only the latter

two have proved to be functional.

In eukaryotic cells microinjection technique is used to transfer DNA. Recently, it has been shown that individual metaphase chromosomes from human cells can be taken up by tissue culture cells and their genes expressed.

#### DNA cloning

Foreign DNA may be transcribed in a new host during the replication of vehicles. Along with vehicles the passenger DNA also replicates and forms a single copy, multiple copies of specific DNA fragment are obtained. This is known as DNA cloning.

Opinions differ considerably regarding the merits and demerits of genetic engineering. On the positive side, genetic engineering raises the possibility of bringing about new gene combinations which do not occur in nature and a better understanding of hereditary diseases and their cure by gene therapy. The transfer of 'nif' genes to cereals could be of tremendous help in solving the food problem. The cloning of eukaryotic genes like insulin in bacteria may be of commercial value. The

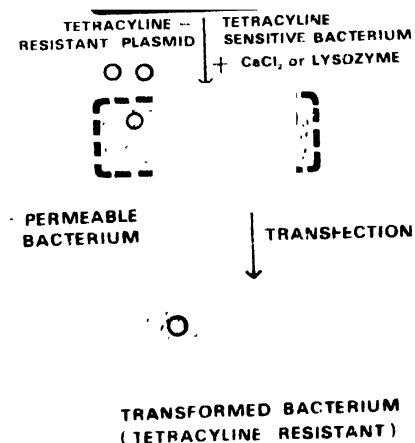


Fig. 10. Transfer of foreign DNA into the host

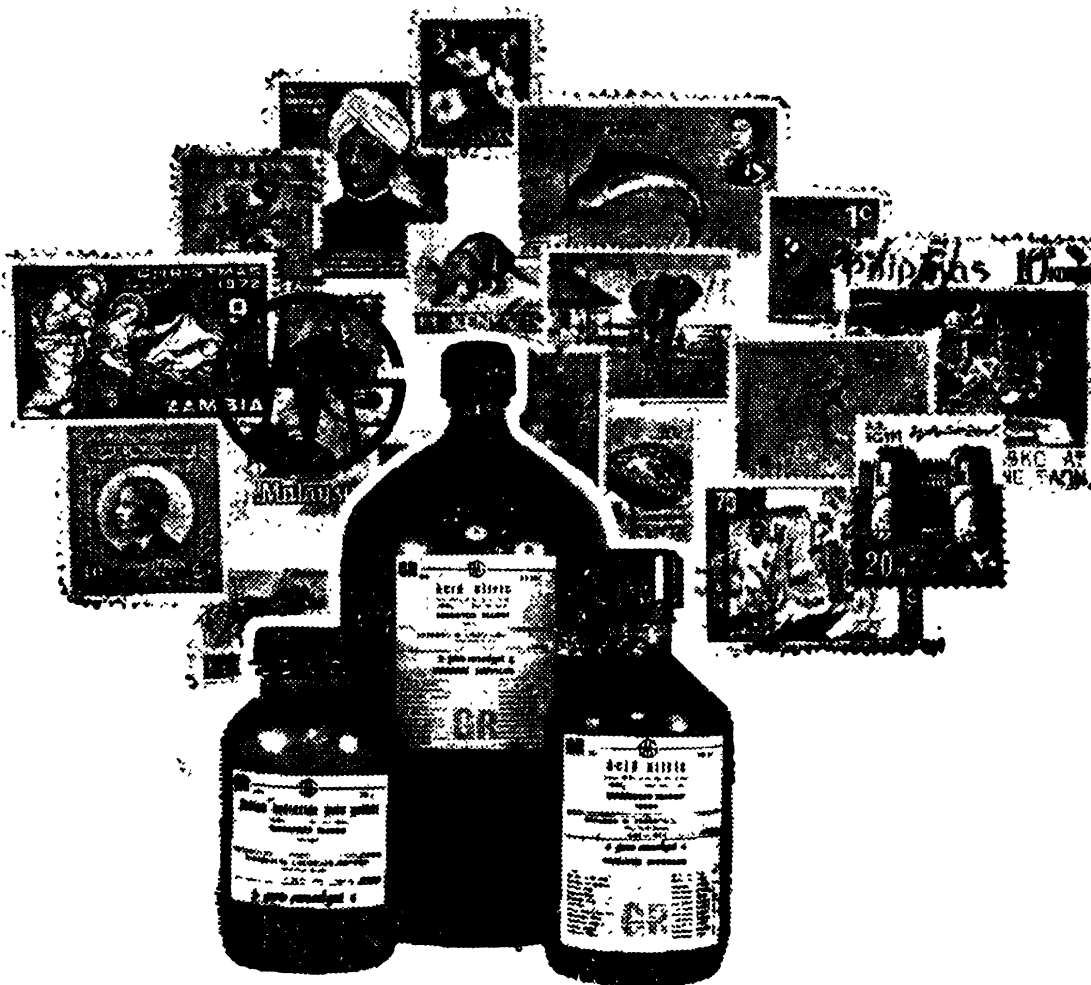
(Continued on page 281)

## FROM EXPERIENCE COMES TRUST IN QUALITY—THE INTERNATIONAL WAY

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# SCIENCE SPECTRUM

## "Beautiful" worlds around Jupiter

**W**HICH is the most beautiful photo that the Voyager spacecraft took of Jupiter and its satellites? Obviously, that close-up view of Jupiter itself! Yellow blobs, brown wavy curves, the orange hues—all blended together in harmony, matching only the surrealistic paintings of J.M.W. Turner, make Jupiter one of the most beautiful and bizarre worlds. Nobody, not even the NASA scientists, had expected the face of Jupiter such a rich blend of colours and variety. But ask an astrophysicist the same question. He would undoubtedly say that the photos of Jupiter's four inner satellites, called Galilean satellites (named after their discoverer, Galileo Galilei), which look "good", "drab" and even "ugly", to be the most beautiful ones. Where lies the beauty? In the eyes of the beholder, obviously.

For an astrophysicist the apparently dull photos of the Galilean satellites show a point of remarkable beauty: the various mechanisms that go into making of the solar system, its planets and satellites, are one and the same, differing only in extent. The photos are, moreover, a key to unlock the past lives of these bodies when earth was also in her early stages of evolution. At present many

remarkable features and case histories of the satellites have come to light, and many more will as scientists continue their game of unravelling the past of the satellites by merely seeing their faces. Meanwhile, the study of photos sent by Voyagers have already led to the discovery of the 14th satellite of Jupiter. It is a body only a few dozen kilometers in size nearer to the planet than Amalthea, the innermost satellite of Jupiter.

According to latest theories, when a huge cloud of dust tried to cross over the path of the spiral arm of the galaxy, it collapsed and a process triggered off the formation of sun and nine planets. Just like in the beginning was the word and sentences came subsequently as a combination of words, the planets

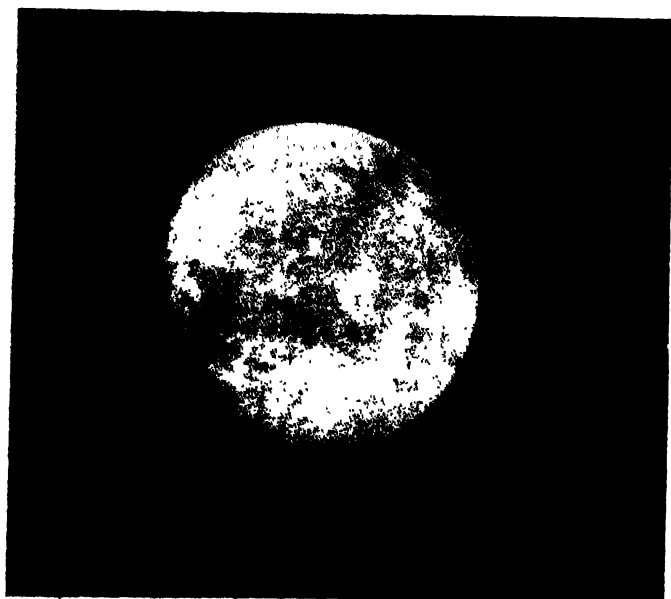
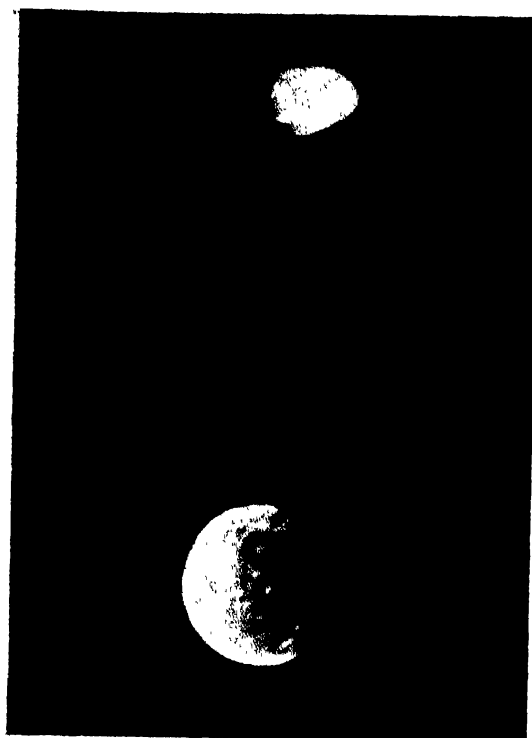
and satellites are a combination of many smaller bodies (See *S.R.*, 15, page 182). In the early days of evolution, the dust coalesced to form pebbles, and pebbles coalesced to form bodies of the size of one to ten kilometer and more, until satellites and planets came into being. Obviously, when the larger bodies had just formed, a lot of chunk of free-floating matter was drifting in empty space in the solar system. These chunks frequently collided with satellites and planets to either merge with them or create craters on their surfaces.

So by studying the faces of various planets and satellites much is gained about their past lives, which will eventually throw light on the evolution of the solar system. Simple deductions, such as, the older a satellite or planet is more craters it would have; more clearer is the relief of craters, younger it is, go a long way in unravelling the past of various heavenly bodies. In studying the evolution of solar system, Jupiter and its satellites are of special interest. In fact, one can easily say that Jupiter and its satellites form a scale-down solar system. For instance, just as the volumes of the inner planets increase and their densities decrease with distance from the sun, the respective characteristics of the Galilean satellites vary with distance from Jupiter.

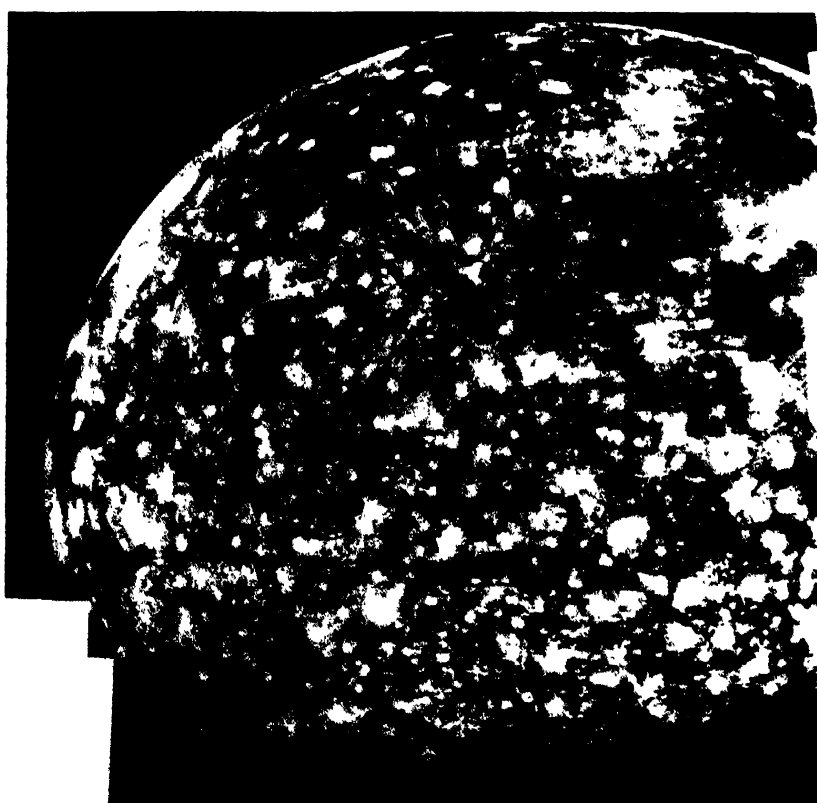
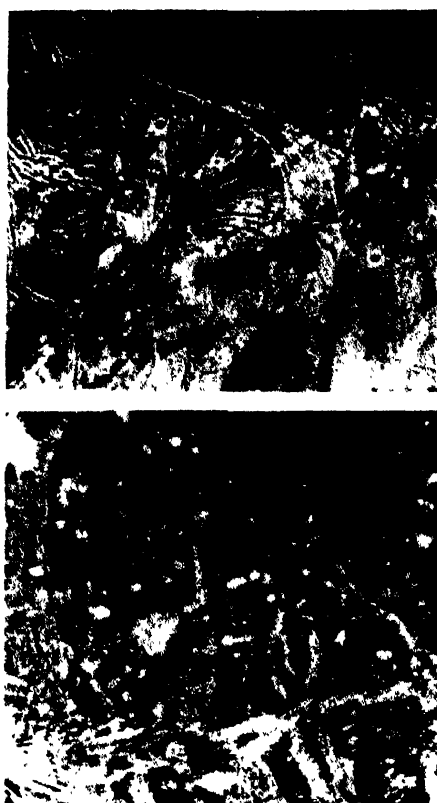
Recent studies of Voyager photos have further shown that even the past lives of the Galilean satellites are similar in proportion to those of

Table 1

SATELLITE	DIAMETER (KILOMETERS)	MEAN DISTANCE FROM JUPITER (KILOMETERS)	ORBITAL PERIOD (DAYS)	BULK DENSITY (GRAMS PER CUBIC CENTIMETER)	MASS (MOON = 1)	CLOSEST APPROACH (KILOMETERS)	
						VOYAGER 1	VOYAGER 2
AMALTHEA	155 x 270 (± 8)	109,900	.49	?	?	420,100	558,270
IO	3,638 (± 10)	350,200	1.77	3.53	1.21	18,840	1,127,920
EUROPA	3,126 (± 10)	599,500	3.55	3.03	0.86	732,270	204,030
GANYMEDE	5,276 (± 10)	998,800	7.16	1.93	2.03	112,030	59,330
CALLISTO	4,848 (± 10)	1,898,900	16.69	1.79	1.46	123,980	212,510



**The moons of Jupiter (*Clockwise from top left*), Volcanoes on Io:  
Amalthea; Callisto; Ganymede and Europa (*Courtesy: USICA, New Delhi*)**



Patterns on Ganymede (*left*). The distant view of the satellite (*bottom*) shows the criss-crossing bands. The nearer view (*top*) shows the complex patterns of ridges and grooves. A view of cratered Callisto (*right*) shows the ring system with a central bright patch.

the inner planets of the solar system. Before this is discussed, it is better to know what the Galilean worlds looked like before and after the Voyager missions last year. Earlier, it was suspected that Io was rich in sulphur, and the surfaces of the other three satellites were covered with water ice in varying amounts. Like our Moon, all of them always keep one of their faces turned towards Jupiter. For other details, see Table 1.

Only three years before Voyagers discovered the volcanoes of Io, a group of astronomers had predicted their presence. It was estimated that varying amount of Jupiter's powerful gravitational force on the satellite induce in it heat energy, which gets released in form of volcanoes. Voyager discovered about eight active volcanoes on the surface of the satellite.

The plumes of the volcanoes have velocities in the range 500 to 1000 km/sec, rise up to 70 to 300 km above the surface of the satellite and live between a few months and a few years. The discovery of the volcanoes was quite an accident, however. It was only when an umbrella-like cloud, which could not be explained by any other way, was seen on a long distance, overexposed photo of the satellite that search began for other volcanoes. In fact, Voyager-2 was manoeuvred such that it could observe the volcanoes on the satellite for a few hours. This curiosity was natural to space scientists. For the first time they had discovered a heavenly body which is internally active like earth.

On the orange-yellow surface of the satellite was also observed

patches of blue, diffuse and varying in size, especially in the southern polar region. After much speculation astronomers have now arrived at the conclusion that they are frozen remnants of sulphur and sulphur dioxide released through many faults on the surface of Io. In fact, liquid sulphur and sulphur dioxide present beneath the surface of satellite in sizes as large as oceans, like aquifers on earth, get leaked out through faults and at the prevailing low temperature and highly low pressure evaporate violently but to form frost. The frost settles down on the scarps, eroding them in the process.

While Io is brimming with activity, the other three Galilean satellites look drab and inactive. Next to Io is Europa, which is of the size of our Moon. White in appearance, it has global markings and patterns

on its surface, besides craters hundreds of millions to billions of years old. Vast tangles of intersecting lines estimated to be tens of km in width and thousands of km in length also cover certain portions of the satellite. As the surface of the satellite cooled, oceans froze and the resulting expansion led to the formation of these stripes-like cracks. Absence of craters at many regions on the satellite's surface indicates that they have been filled up with water risen from beneath, the heat being provided by internal radioactivity. Or, the craters might have been produced when the crust of the satellite was soft and warm.

The next two Galilean satellites, Ganymede and Callisto, are both of the size of the planet Mercury. One common feature—a system of concentric rings—on their surfaces shows that in an earlier period in their evolution, they had evolved in similar conditions. The ring system on Callisto has rings about 50 to 200 km apart, and their outermost diameter is about 1500 km. At the centre of the system is a bright circular patch, 600 km in size, about 10 degree North of equator. Similar rings, but much worn out and having no central bright patch, are seen on Ganymede. It is believed that millions of years ago when the surfaces of these two satellites were soft, a small body hit each of them. Its impact set up oscillations which finally readjusted the surface of the satellite to produce the rings system. In the case of Ganymede the ring system and the central crater were worn out due to impact by other bodies. Further, ridges of the ring system on Callisto are flat-topped and those on Ganymede have furrows. This difference shows that the histories of evolution of the two satellites are different beyond a particular stage.

Ganymede's surface resembles Moon's but it has some patterns not found on the latter's surface. Grooved

terrains surround the heavily cratered terrain of the size of a few kilometers. The former has parallel ridges and troughs, each 5 to 15 kilometers long. There is in addition a large circular dark region of an ancient crater, one third of the entire hemisphere, which can easily be seen through a powerful telescope.

Consider now the similarities seen between the inner planets and Galilean satellites. In so far the planets are concerned the rates at which craters were produced on each of them by smaller bodies are more or less the same. In contrast, the cratering-rates of the Galilean satellites are far less, as much as by a factor of 10 to 100. Reason for such low rates is attributed to the powerful gravitational field of Jupiter, which helps the planet in not only attracting stray smaller bodies but also in deflecting them away. The result is that few bodies are able to strike the satellites, but if in case they do, they strike with a far greater force creating thereby a bigger crater. So if a graph is drawn between the sizes of craters on a body and the frequency of the formation of craters, it has been found that Callisto and Ganymede have case histories similar to those of Mars, Moon and Mercury. (*Scientific American*, January 1980). The mission of Galileo spacecraft to Jupiter in the next few years will—let's hope—further show the similarities between these satellites and planets.

DILIP M. SALWI

## Acid rains

ONE hardly ever hears of a rain that kills fish. Southern Norway is the region where such a thing has occurred, and it can occur anywhere in the world when rain water contains sufficient amount of sulphuric and nitric acids. Such rains are called

'acid rains'. An acid rain is defined as a rain or snow at a pH value below 5.6 (pH value measures the concentration of hydrogen ion in a solution. pH value decreases with increasing concentration of hydrogen ion in a solution, and vice versa). Studies show that the acidity of rain water is continuing to increase all over the world.

How are the acids in acid rain produced? Sulphur dioxide and hydrogen sulphide gases react with oxygen and water vapour in the atmosphere to produce sulphuric acid and, likewise, various nitrogen oxides are converted into nitric acid. Sulphur dioxide, hydrogen sulphide and various nitrogen oxides are produced during both natural and human activities. Volcanoes are the chief natural source of sulphur dioxide and hydrogen sulphide while biological processes are the chief natural sources of various nitrogen oxides. Industries and power stations, which use fossil fuels such as coal, are the chief human source of all the pollutant gases.

In addition to the aforementioned acids, dust and debris, ammonia, sea sprays and carbon dioxide gas affect the acidity of rain water. The acidity of rain water will depend upon the relative concentration and properties of the different compounds in atmosphere. The dust and debris, which are swept up from the ground by winds, contain alkali ions which decrease the acidity of rain water. Ammonia formed during the decomposition of organic matter reacts with water vapour in the atmosphere to form ammonium hydroxide, which also decreases the acidity of rain water. Sea sprays contribute a number of ions of sodium, potassium, calcium, magnesium, chlorine and sulphate. Carbon dioxide gas, which is present even in unpolluted air, combines with water to form carbonic acid, which is a weak acid and has a pH value of 5.6 under normal conditions.



Not all acid rains have effect on plants, animals or human beings. The effect depends upon various factors including the acidity and total amount of rainfall, and the type of minerals in the regions over which the rain falls. In places where the acidity and the total amount of rainfall is low and the minerals in the region have a capacity to neutralise acid in the rain, the effect of acid rain will be less.

Researches have shown that acid rain has a marked effect on fresh water eco-system which is underlain with rocks having high concentration of silica and silicates. These rocks are so hard that weathering cannot dissolve them. The surface water in such an eco-system, therefore, contains little or no ions, which can neutralise the acids in the rain. The result is that fish population is affected.

Though acid rain has been falling for more than two centuries, it attracted the attention of scientists in the 1950's only and that too after smog threatened life in London. One of the earliest solutions suggested was to construct tall chimneys in industries, power stations, etc., so that the pollutant gases are released into air at a higher altitude. Tall chimneys more than 180 metres in length, some even about 400 metres high, are being used all over the world. This measure helped in reducing the concentration of acids in the rains, but at the same time it had a harmful effect. Winds disperse the pollutant gases over a larger area even across international boundaries. The result is that places free of industries or any other sources of the pollutants, also began to receive acid rains.

An interesting situation arises when the movement of a wind-driven air-mass containing the pollutant gases is obstructed by mountains. It is found that rain water on the windward side of the mountains is more acidic than on their leeward

side. For example, an air-mass containing pollutant gases travels hundreds of kilometres from its source in the British Isles and Central Europe, over North Sea and over land of relatively low mountains before reaching the mountainous Norwegian coast.

An instrument, called scrubber, is being increasingly used to minimise the amount of pollutant gases

ves the pollutant gases from waste gases emanating from the chimneys. In industries, power stations, etc., fossil fuels are also being increasingly replaced by other fuels so as to reduce the production of the pollutant gases. Coal containing less amount of sulphur and nitrogen is in use where alternate fuels are not available.

## Corrosion of steel in concrete

**N**ORMALLY concrete protects steel against corrosion. But then, how does steel become corroded to give a poor durability to concrete?

Steel is made from iron produced in a blast furnace. This is an energy-intensive process. The metallic iron is in a high energy stage and therefore has the tendency to revert to a state in which it is found in nature, i.e., oxide form. The change from metallic to oxide state is a process known as corrosion and rust is its product.

### Why corrosion ?

Presence of moisture is essential to cause corrosion of iron. The amount of water present in the cement governs whether or not the corrosion will occur and, if so, at what rate. The molecules of water are present in the cement matrix. Silicates of calcium are the main constituents of cement which combine with water for the main cementing action to form calcium silicate hydrate with the release of large quantities of calcium hydroxide. The latter quickly forms a saturated solution in the hydrating cement paste with the rise in pH (11.4). The presence of alkali ions ( $\text{Na}^+$  or  $\text{K}^+$ ) in the pore fluid further increases pH of the solution to about 13.2. This solution acts as an electric conductor or electrolyte in the metal-embedded concrete. As

such, an electrical potential is developed which depends upon the metal embedded. If the metal tends to go into solution, i.e., releases its metal ions, the metal is said to corrode. Whenever dissimilar metals are embedded in concrete and are in electrical contact with one another, the more anodic of the pair will corrode. Therefore, any dissimilarity in the steel structure can cause corrosion of the latter.

A similar type of concentration cells may be formed where a single piece of steel is in contact with a solution at two different concentrations. Commonly, this happens due to variations in oxygen concentration when one portion of the steel bar is exposed to air and the other is well compacted in the cement.

Again, concrete changes its chemical nature on exposure to the atmosphere. This process is known as weathering, and occurs due to the reaction between carbon dioxide (or other acidic vapours) in atmosphere and the calcium hydroxide in the cement phase. The reaction slowly lowers the pH of the concrete, resulting in corrosion.

The presence of chloride ions accelerates corrosion of steel in concrete due to various reasons, viz., reduction of alkalinity, increase in conductivity of electrical corrosion

current and reducing passivating effect of hydroxyl ions.

Steel in the concrete, or otherwise, is inhibited by the formation of a suitable film of hydroxide or oxide on the metallic surface. This film prevents further corrosion. If the film is damaged due to any reason, it is reformed if the oxygen supply is available.

#### Prevention of corrosion

The first requisite to contain

corrosion is to cut steel from exposure to oxygen and water of the atmosphere. For that purpose, thicker layers of concrete should be laid. Another important point is the correct water/cement ratio with the use of minimum water required for complete compaction of cement. Galvanisation (putting on a metallic coating of zinc on the steel) also helps prevent corrosion.

C.B. SHARMA

## Himalayan hot water springs

THE tradition-bound Indian cultural heritage considers hot springs or geo-thermal springs as a unique creation of God or as springs enjoying the blessings of ancient sages. Lakhs of pilgrims carry with them water from hot springs which they consider a divine liquid. But, this age-old belief is far from the truth. Scientific research has proved that hot springs are simple, natural phenomena. They occur wherever sufficient heat is available to raise the temperature of the sub-surface waters.

A typical hot spring consists of a central conduit with ramifying

Table 1. Showing location, elevation, temperature and pH of main Himalayan hot springs

Name	State	Elevation (meters)	Temperature (°C)	pH
Kasol	H.P.	1600	41	7.30
Manikaran	H.P.	1760	45 to 97	7.45
Khirganga	H.P.	2000	50	7.45
Katalth	H.P.	—	43	7.55
Tatiwani	H.P.	—	57	7.75
Vasisth	H.P.	2120	58	7.38
Puga	J & K	4490	35 to 83.5	7.40-7.30
Chumatang	J & K	—	83.6	8.10
Badrinath	U.P.	3367	56	7.40
Gaurikund	U.P.	1942	53	7.45
Tapoban	U.P.	1919	53	7.10
Gangani	U.P.	1855	53	7.25

passages leading from it (Fig. 1) The accumulated underground water gets super-heated, i.e., heated above the boiling point, whereupon it boils and upsurges on to the surface. Sometimes, when the critical temperature is exceeded, high pressure steam is formed which gives rise to a geyser.

A miniature township is gradually coming up in the bracing climate of a picturesque valley south-east of Leh following geothermal explorations, which are now being carried out in this area. Situated at an altitude of 4450 meters, this area called Puga valley, is about 15 kilometers long and one kilometer wide. It contains one of the several hot spring

fields that occur in the north-western Himalayas (Fig.2).

The temperature of Himalayan hot springs normally ranges from 45°C to 90°C at the surface. They are characterized by shimmering hot waters, patches of warm ground, ejection of sulphurous gasses and geo-thermal deposits of borax and sulphur. These deposits are generally found as encrustations on the surface rocks of the hot spring area (Fig. 1). A few of these springs have

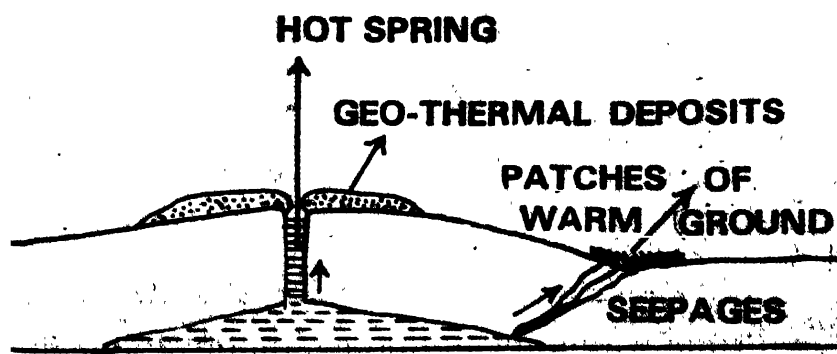


Fig. 1. Hypothetical section of a hot spring field

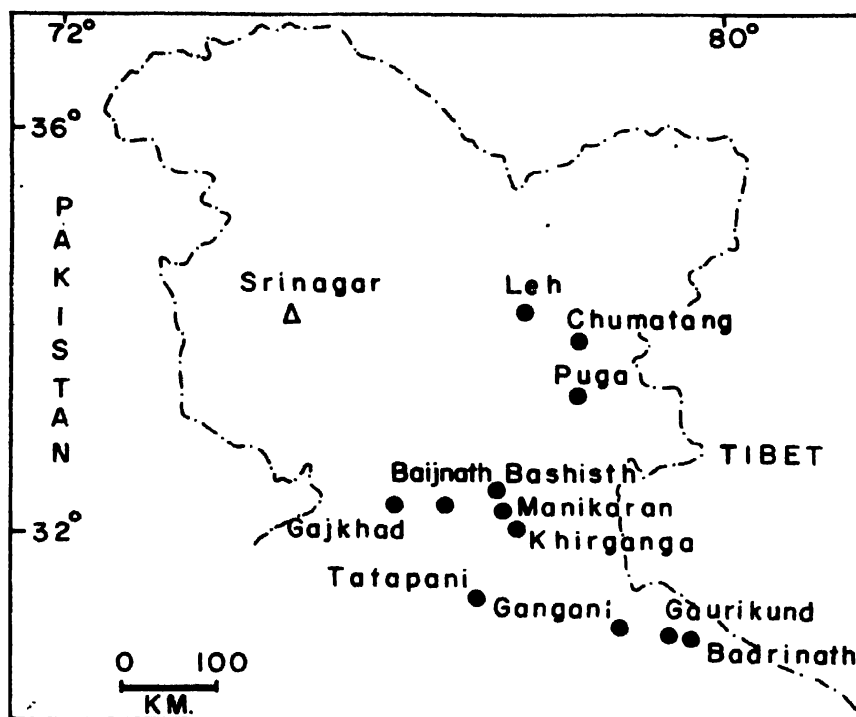


Fig. 2. Map showing location of NW-Himalayan hot springs

ges around 170°C as calculated by Na/K geothermometry. Table 1 shows the elevation, temperature and pH of some Himalayan geothermal springs.

Though several theories have been advanced, the exact mode of origin of these springs are not yet known. One theory is that compressional forces may cause melting of the earth's crust and emplacement of granitic bodies (which are thought to be igneous in origin). Although recent volcanic activity is absent in the Himalayas, the northward thrust of the Indian shield under the Eurasian plate, has given rise to a large fracture system which may have facilitated the emergence of these hot springs. It has been observed that the geothermal springs are generally concentrated on both sides of this fracture system (Fig. 3). Only a few warm-to-hot springs are found in the lower Himalayas and Siwalik Hills. Some of these springs are also found at the margins of the Shillong plateau in the north-eastern region.

Based on present techno-economic aspects, M.L. Gupta and S.B. Singh (1977) of the National Geophysical Research Institute, Hyderabad, have given three main condi-

boiling temperatures corresponding to the altitude of their place of occurrence and in a few cases, mild geyser activity is seen.

Geochemical analysis of the hot waters obtained from Chumatang area, situated north of Puga valley, shows a high concentration of sodium bicarbonate and sulphate along with  $\text{SiO}_2$ . The temperature of the underground superheated water reservoir, as estimated by sodium-potassium atomic ratio, works out to be between 200°C and 225°C. In this method of geothermometry, the temperature is estimated by calculating the ratio of sodium-potassium ions, then comparing it with the absolute temperature and standard heat of reaction at a given temperature. In the Parbati valley of Kulu district (H.P.), where the hot springs are located at Kasol, Manikaran and Khirganga on the right bank of the Parbati river, chemical analysis of the thermal waters shows the presence of a wide variety of elements including lithium, fluorine, strontium and silver. The

temperature of the reservoir here has been worked out to be about 200°C. Hot springs of Gangani, Badrinath and Gaurikund, lying in the lap of the U.P. hills, occur in central Himalayan granitic rocks. The reservoir temperature here ran-

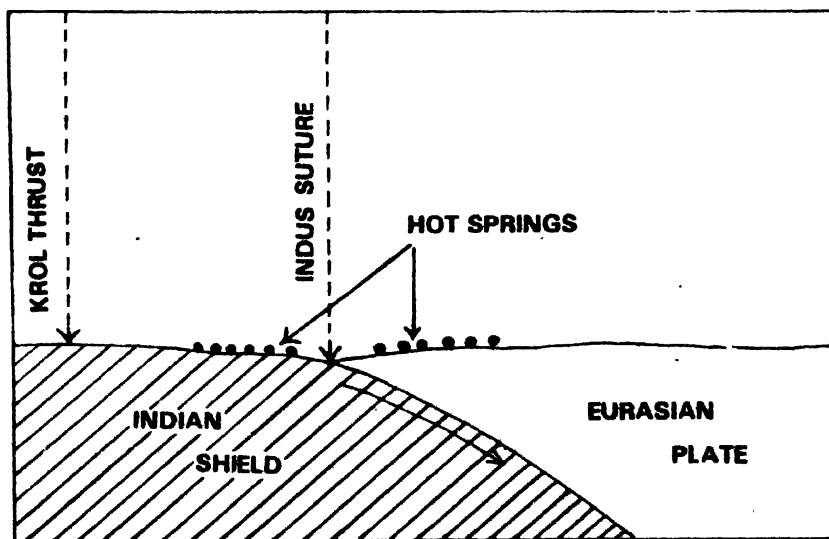


Fig. 3. Position of the Indus suture line and hot springs

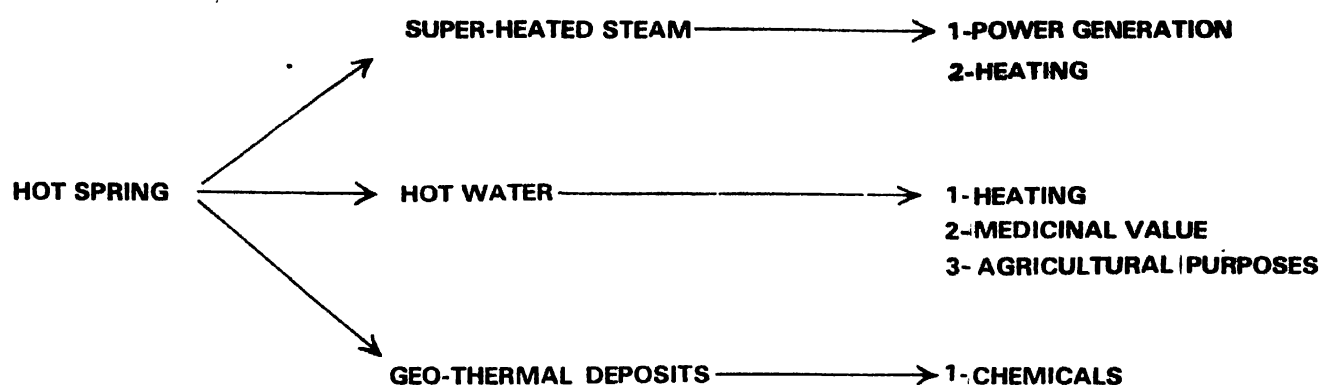


Fig. 4. Uses of hot springs

tions for the occurrence of potential geothermal areas for power generation and other multipurpose applications. These are: (a) the occurrence of a natural source of heat, (b) a water source and a suitable reservoir for storing water, and (c) a caprock to confine the circulating fluids.

In the Himalayas, wood and fossil fuel are at present the main sources of energy. With the quick depletion of our forest resources, on the one hand, and the high cost of transportation of fossil fuel from the plains on the other, the time has come for people living in the north-west Himalayas to switch over to geothermal energy. The Himalayan hot springs have, for centuries, been

the destination of thousands of pilgrims. Now there is need to harness them. Potential exists for socio-economic development of the mountains, by providing basic needs of food through greenhouse cultivation, poultry-sheep farming at higher altitudes, preservation of fruits in geothermal storages and heat pumps for agriculture. Besides, non-polluting geothermal power can be produced at costs varying between one-third and half the cost of energy obtained from conventional sources.

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## Fermatians

FROM the beginning of 17th century, mathematicians have been keen on finding a formula which would yield primes, that is, numbers which have no factors other than itself and '1', for example, numbers such as 2, 3, 5, 7, 11, etc. Pierre de Fermat (1601-1665), a French mathematician, conjectured that  $F^m = 2^{2^m}$  will always yield primes for

the values of  $m = 0, 1, 2, 3, 4, 5$ , etc. In fact,  $F_m$  is prime for each of the values of  $m = 0, 1, 2, 3, 4$ . But the Swiss mathematician Leonard Euler (1707-1783) found in 1732 that  $F_5$  has the factor 641 and is thus composite. An elementary proof not involving explicit divisions shows that 641 divides  $F_m$ , as given below:

It is easy to see that  $5^4 + 2^4$  and  $5 \cdot 2^7 + 1$  are each equal to 641.

Now  $641 = 5^4 + 2^4$  divides  $5^4 \cdot 2^{28} + 2^{32}$ , because  $5^4 \cdot 2^{28} + 2^{32} = (5^4 + 2^4) 2^{28}$ .

Again,  $641 = 5 \cdot 2^7 + 1$ . It divides  $5^1 \cdot 2^{28} - 1$ , since  $(5 \cdot 2^7 + 1) (5 \cdot 2^7 - 1) = (5 \cdot 2^{14} + 1) - (5^2 \cdot 2^{14} - 1) (5^2 \cdot 2^{14} + 1) - 5^4 \cdot 2^{28} - 1$ .

Thus 641 divides  $5^4 \cdot 2^{28} + 2^{32}$

$\therefore 641$  also divides  $5^4 \cdot 2^{28} - 1$

It therefore follows that 641 is a divisor of the difference of the numbers  $5^4 \cdot 2^{28} + 2^{32}$  and  $5^4 \cdot 2^{28} - 1$ , i.e., the number  $2^{32} + 1 = F_5$ .

Later, all the values of  $F_m$  from  $m=6$  to  $m=18$  (apart from  $m=17$ ) were found to be composites. At present quite a good number of values of  $m$  are known for which  $F_m$  is composite. The largest known composite  $F_m$  is  $F_{1945}$  which is a huge number. It is as yet unknown whether  $F_{17}$  is a prime or composite.

Father Mersenne (1588-1648), a French clergyman and a contemporary of Fermat, conjectured that  $M_p = 2^p - 1$  will yield primes for the following prime values of  $p$ , namely,  $p=2, 3, 5, 7, 13, 17, 19, 31, 67, 127$  and 257 only, and no other values of prime  $p$  lying between 2 and 257. If  $p$  is composite,  $2^p - 1$  can easily be factored. In 1880 it was found that  $M_p$  is prime for  $p=61$ , which is not in Mersenne's list. This was an error of omission on the part of Mersenne.

In 1903 another error was detected by the American mathematician F. N. Cole, who found that  $M_{67}$  is a composite. It was an error of commission. Once Cole was asked how long it took him to find this out. Cole replied 'three years of Sundays'. In one of his books, the American mathematician E.T. Bell (1883-1960) has given a graphic account of how Cole had demonstrated this result in a meeting of the members of the American Mathematical Society. In October 1903, Cole was asked by the President of the Society to read out the paper 'On the Factorisation of Large Numbers' which he had presented for discussion at the meeting. Cole, a man of few words, approached the blackboard and with chalk in hand began to calculate  $2^{67}$ . Having calculated, he subtracted 1 from this. Then moving to a clear space on the blackboard he began to calculate in long hand  $1\ 9\ 3\ 7\ 0\ 7\ 7\ 2\ 1 \times 7\ 6\ 1\ 8\ 3\ 8\ 2\ 5\ 7\ 2\ 8\ 7$ . When the calculation was finished it was found that the two results agreed. Without a word Cole went back to his seat while everybody present in the meeting applauded him. Nobody raised a question.

In 1931 the American mathematician D. H. Lehmer showed that  $M_p$  is composite for  $p=257$ . Later, two more errors were found in Mersenne's conjecture:  $M_{89}$  and  $M_{107}$  were found to be primes. So five errors in all were found in Mersenne's conjecture—'three' of omission and 'two' of commission—in a period of three centuries prior to the advent of computers (for a recent status-list of Mersenne numbers see *The world of primes*, S.R., August 1977, p. 501).

#### Fermat numbers or Fermatians

It is interesting to note that all odd prime numbers, Fermat numbers, and a few other numbers satisfy an interesting relation which is written symbolically as  $N|2^{N-1}-1$ , i.e.,  $N$

divides  $2^{N-1}-1$ . Numbers  $N$  which satisfy the relation ' $N$  divides  $2^{N-1}-1$ ', written symbolically as  $N|2^{N-1}-1$ , are called 'Fermatians'. That all odd primes satisfy this relation follows from an important theorem due to Fermat. A demonstration that Fermat numbers satisfy this relation was given in *On a conjecture of Fermat and few others* (S.R., April 1968). It is not difficult to show that Mersenne numbers also satisfy this relation. Fermatians are important in the history of number theory because many such numbers which were not primes in reality were thought of as primes such as Fermat numbers other than  $F_1, F_2, F_3, F_4$ . Likewise, some Mersenne numbers which were not primes in reality were thought to be primes as has been noted earlier. Composite Fermatians masqueraded as primes before they were found out because they satisfied the same relation  $N|2^{N-1}-1$ , like all primes. However, this relation is not sufficient for establishing primality as was apparently believed by some 17th century mathematicians including Fermat. This relation is, in fact, a necessary one only. In other words, if  $N|(2^{N-1}-1)$ , which means  $N$  does not divide  $2^{N-1}-1$ , we can always say that  $N$  is not a prime, but when  $N|2^{N-1}-1$ , we cannot always be sure that  $N$  is a prime. The only sufficient relation which establishes primality of any number is the following, due to an 18th century British mathematician, John Wilson (1741-1793).

If  $N|(N-1)!+1$ , i.e.,  $N$  divides  $(N-1)!+1$ , then  $N$  is a prime. Here  $(N-1)!$  means the product of all the numbers from 1 to  $N-1$ , i.e.,  $(N-1)! = 1 \times 2 \times 3 \times 4 \times 5 \times \dots \times (N-1)$ . A proof of this was given by the French mathematician J. L. Lagrange (1736-1813). (Lagrange was of Italian origin but naturalised as French.)

#### Composite Fermatians

A great challenge to mathemati-

cians was finding of Fermatians which were not primes. Compared to primes, composite Fermatians are rare indeed. The first ten such composite Fermatians are listed below:

341	1729
561	1905
645	2047
1105	2465
1387	2701

Two mathematicians, P. Poulet of Belgium and D. H. Lehmer of America, have tabulated all composite Fermatians less than  $10^8$  (i.e. less than 100000000). From their tables it is found that composite Fermatians are quite rare compared to primes. There are 5 7 6 1 4 55 primes less than  $10^8$ , whereas the number of composite Fermatians less than  $10^8$  is only 2043. The numbers of composite Fermatians less than  $10^4$ ,  $10^5$ ,  $10^6$  and  $10^7$  are 22, 79, 247 and 750. The number of primes less than  $10^4$ ,  $10^5$ ,  $10^6$  and  $10^7$  are 1229, 9592, 79498 and 664579 respectively.

A categorisation of the aforesaid 2043 composite Fermatians less than  $10^8$  reveals that of these 252 are Carmichael numbers, also called 'absolutely pseudo-primes', two are Mersenne numbers, two are Wieferich squares, none are Fermat numbers, (the first composite Fermat number  $F_5$  is greater than  $10^8$ ), the remaining belong to none of these classes.

#### Wieferich squares and Carmichael numbers

Wieferich squares are those squares of prime numbers ' $p$ ' which satisfy the relation  $p^2|2^{p-1}-1$ , i.e.,  $p^2$  divides  $2^{p-1}-1$ ,  $p$  being a prime. Example,  $p^2=1093^2$ .

Carmichael numbers, also called 'absolutely pseudo-prime numbers', are numbers ' $m$ ' such that  $m|a^m-a$  i.e.,  $m$  divides  $a^m-a$ , for every ' $a$ ' relatively prime to  $m$ . An example is  $m=561$ .

It may be pointed out that composite Fermatians are occasionally referred to as 'pseudo-primes' presumably because they masqueraded

for a long time as primes before they were found out.

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## What are drug interactions ?

**D**RUG interactions mean the modification of the effect of one drug by the presence of another. This can occur by direct or indirect means. Interactions may be beneficial or hazardous. They may be of major clinical significance or minor or some times of no clinical significance at all. Interactions of harmful or hazardous effects are called 'Adverse drug reactions'. Previously the term 'Incompatibilities' was used for adverse drug reactions but it has been now discarded. 'Incompatible' implies that two drugs cannot be given concomitantly to a patient. In most cases, however, the interacting drugs may be given if appropriate precautions such as alteration in dosage, change in the route of administration, or some similar measures are taken. Sometimes two or more drugs are administered together as a fixed dose mixture known as 'drug mixtures'.

The toxic effects of drug interactions have to be carefully monitored during clinical trials before putting the multi-drug preparations in the

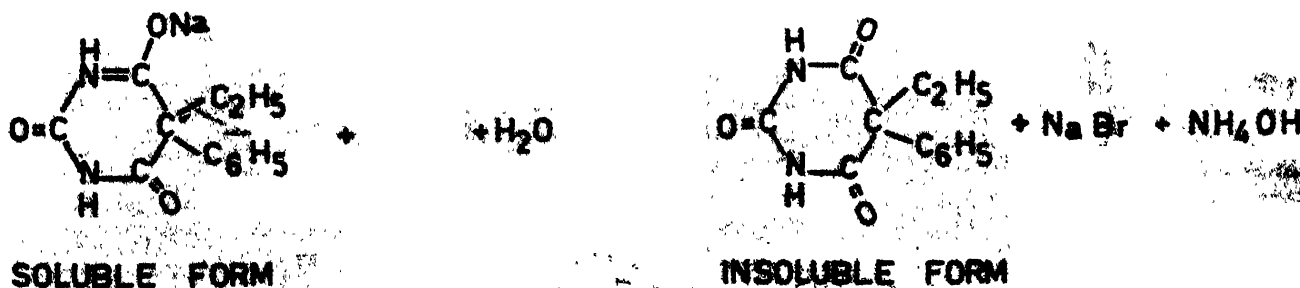
market. So combination of drugs must not be used for treatment of patients unless the drug interactions of this combination are well studied. To know the effects of drug interactions, understanding the concept of the mechanisms of drug interactions is essential. In some cases more than one mechanism may be involved. The following is a general classification of drug interaction mechanisms.

*Physico-chemical interactions* are interactions that occur in solution prior to administration. For example, bromide is prescribed with phenobarbitone to have a synergistic antiepileptic action as bromides are known to depress the convulsions associated with epilepsy. But if ammonium bromide and soluble barbiturates are present together in solution, ammonium bromide interacts chemically with soluble barbiturates and converts them into insoluble barbiturates (Fig. 1). So to overcome this interaction ammonium bromide can be replaced by equivalent amount of sodium

bromide without reducing the activity.

*Pharmaco-kinetic interactions or ADME interactions* are interactions that result in altered absorption, distribution, metabolism or elimination of a drug. This group includes those interactions in which gastrointestinal absorption of a drug is affected, drug metabolism is stimulated or inhibited or urinary excretion is enhanced or inhibited. For example, tetracyclines cannot be taken with divalent or multivalent cations as the absorption of them is inhibited by chelation between tetracyclines and heavy metals. Antacids containing divalent or trivalent cations also impair the absorption of orally administered tetracyclines. Sometimes patients suffering from fever or other complaints are prescribed tetracycline by the physician and advised to take bread and milk as diet. What does the ignorant patient do? He takes tetracycline capsules with milk which contains calcium. This calcium impairs the absorption of tetracycline thereby the therapeutic level of tetracycline is not maintained.

For proper distribution of a drug, competition between two drugs for the same binding site on plasma proteins may have important consequences. Phenyl-butazone increases the anticoagulant activity of warfarin by replacing the protein bound warfarin. Thereby more free warfarin is available in the blood. Another example is salicylate. Though it has no anti-inflammatory action by itself, it potentiates the anti-inflam-



matory activity of corticosterone when both are administered. The mechanism is that protein-bound corticosterone is replaced by salicylate which has more binding capacity towards proteins and free corticosterone is available for eliciting its action on the receptor site.

Drug interactions at metabolic level also play an important role. For example, isoniazid inhibits hydroxylation of diphenylhydantoin (anti-convulsant) and simultaneous administration of both the drugs can cause toxic reactions. Another clinically significant drug interaction is caused by chloramphenicol when administered with tolbutamide. The former inhibits the microsomal activity, resulting in impaired tolbutamide metabolism. Hypoglycemic coma may result if both of them are given together.

Coming to the interactions at excretion level, one drug may block the renal excretion of another by competing for the same tubular transport system. This is exemplified by carimide blocking the excretion of penicillin and thereby prolonging the

penicillin plasma level.

Hundreds of reports about drug interactions have flooded the clinical literature in recent years. The physician as well as the pharmacist must be familiar with drug interactions of established clinical significance. Interactions may involve not only the drugs that the physician prescribes but also those taken without prescription either by the patient on his own or in consultation with a pharmacist, and certain foods. Medical practitioners, being busy persons, may not be able to keep abreast of the reports about clinically significant drug interactions. It is here that the pharmacist plays a vital role by avoiding the dispensing of combination of drugs with possible adverse drug interactions and by suitably advising the physicians. The pharmacist is a vital link between the doctor and the patient.

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## Genetic engineering and commercial biosynthesis of human insulin

**T**HE advancement in the technology of genetic engineering with the breakthroughs in molecular biology like chemical synthesis of genes in the laboratory and the discoveries of miracle enzymes, namely, reverse transcriptase and restriction endonuclease led the biologists to dream about biologically curing several difficult-to-cure diseases like diabetes, cancer, etc. Chemical therapy, which often results in many side effects and sometimes even in quite new diseases, prompted medical and biological scientists to learn

towards biological therapy as a substitute for the former and to lessen the much-talked chemical hazards. The major breakthrough in this regard has been a step for biologically producing the hormone insulin (deficiency of which causes diabetes) on commercial scale. The existing production systems of the hormone are becoming costly and difficult to meet the demand of the patients.

The hormone insulin, whose deficiency causes diabetes (excessive accumulation of glucose in blood) in

peptide chains—A and B. Its immediate precursor is a single polypeptide—proinsulin, which, too, contains two chains (A and B) connected by a third peptide, C. However, according to recent reports of workers, the initial precursor of insulin is another polypeptide called pre-proinsulin which contains more than twenty additional amino acids on the amino-terminus of proinsulin. Hence, the structure of pre-proinsulin molecule can be written as .

$\text{NH}_2$ -(prepeptide)-B-chain-(peptide C)-A-chain-COOH

The alternate commercial synthesis of insulin started with an idea to incorporate the human insulin gene in a simple and efficient microorganism which can multiply fast within a short time and can provide the hormone in considerable amount. The efforts, in this regard, were initiated by Axel Ullrich and his colleagues in W. J. Rutter's Laboratory at the Department of Biochemistry and Biophysics, University of California at San Francisco (USA). Instead of going for the isolation of the DNA sequence (gene) for insulin on the vast stretch of human DNA molecule, they isolated the messenger RNA (mRNA) for pre-proinsulin from rat islets of Langerhans of pancreas (clusters of hormone-secreting cells located in the pancreas of vertebrates. Two types of cells are found: alpha cells which secrete glucagon and beta cells which secrete insulin) and synthesized complementary DNA (cDNA) with the help of the enzyme reverse transcriptase. The cDNA, thus produced, was made to form its complementary helix again in the presence of the same enzyme. Since, this cDNA cannot be inserted into the plasmid (an extra-chromosomal hereditary determinant) DNA in its present form, it was cut in the middle with the

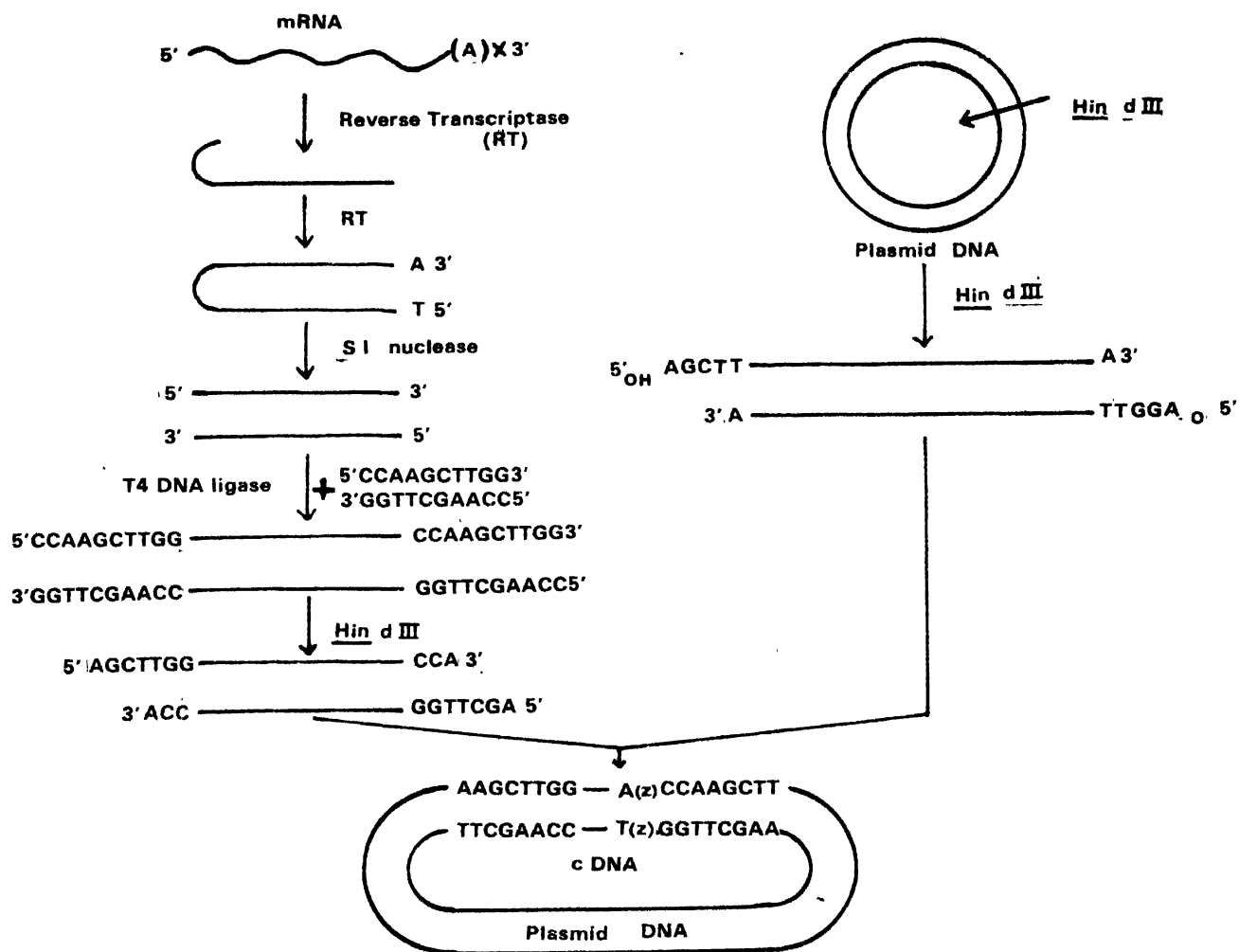


Fig. 1

separate DNA strands of the same insulin gene. The next problem with these authors was how to weld these DNA strands with the plasmid DNA. Here, advantage was taken from the wonderful 'specificity' character of restriction endonuclease. [Restriction endonuclease is a special class of enzymes which can cleave the DNA at specific sites containing the specific DNA sequences (T. P. Singh, S.R., July 1978)]. The specific DNA sequence or recognition site



(synthesized in the laboratory) of the restriction enzyme *Hind* III was used to be added at

the two ends of each DNA strand with the help of T4DNA ligase. These two strands, containing *Hind* III recognition sites at the two sides, were treated with *Hind* III which cleaves recognition sites and leaves loops at the ends of each DNA strand (another characteristic feature of restriction enzymes). These loops help cDNA in chemically joining with the similarly nicked DNA strands having the same type of loops.

On the other hand, plasmid (here pMB9 plasmid) DNA is also cleaved with the same restriction enzyme leaving at the ends of the helix the same type of loops. In fact, the use of a particular restriction enzyme

for adding desired DNA sequence and making loops at the two flanks of cDNA is made by working out a particular recognition site (at the plasmid DNA) and hence its corresponding enzyme. Plasmid DNA and cDNA both having the complementary loops, thus produced, are brought together and made to join with each other under influence of T4 DNA ligase. This gives rise to a recombinant plasmid DNA containing insulin gene within. The entire method is represented schematically in Fig. 1.

Though, the above experiment was a breakthrough in the field of insulin research, it was not free from many inherent shortcomings.



First and the foremost of these is the problem of isolating a pure insulin mRNA from the islets of Langerhans, which is a rich source of RNA-degrading enzyme, RNase. This type of work has been done mostly on globin whose mRNA could be isolated in highly pure form. Second is the test for the genuineness of inserted DNA, that whether this is actually an insulin gene or not. This can be achieved by hybridizing the combinant DNA with mRNA for insulin, isolation of which in pure form is again difficult. Third, after isolation and analysis, the entire proinsulin gene was found distributed among four different clones of plasmid. Success lies in having the entire proinsulin gene as a single molecule within a single cell and not as four different units whose reassembly would be another difficult task to perform. So, the aim of a project on this problem naturally becomes to attain the synthesis of a complete insulin gene together with its flanking gene sequences. The last but not the least trouble with the Ullrich's experiment is the processing of the pre-proinsulin to mature insulin in the recipient host, as this precursor contains many extra peptides.

Vill-Komaroff *et al.* (1978) went a step ahead by incorporating the recombinant DNA (constructed in the manner described above) into the bacterial cell and showing the secretion of complete proinsulin by them, which Ullrich and his group did not try. However, both the works were restricted to the rat-insulin gene only, as the isolation of human pre-proinsulin mRNA was technically difficult and has not yet been accomplished. K. Itakura and associates (1977) at the Division of Biology, City of Hope National Medical Centre at Duarte, California adopted an alternative method to overcome this problem. They used synthesized DNA sequence for the two chains (A and B) of human

insulin and inserted them separately into two PBR322 plasmids by the side of  $\beta$ -galactosidase gene. The recombinant plasmids were separately incorporated into *Escherichia coli* (a human-colon bacterium) cells and the latter were seen to secrete fused  $\beta$ -galactosidase-A chain and  $\beta$ -galactosidase-B chain separately. Later on, A and B chains were isolated in pure form and encouragingly in greater amount (10 mg/24 gm wet cells).

Itakura's method was really a novel approach to the problem. First, they took chemically synthesized DNA of the two chains (instead of using cDNA made from mRNA) separately and incorporated them separately into two different pBR322 DNAs, avoiding the production and processing of extra peptides (in the absence of extra base sequences for different peptides). The other excellent method was to get the two chains detached from the  $\beta$ -galactosidase enzyme in their pure form. To achieve the successful detachment, an extra methionine codon was added at the N-terminus of each gene for A and B chains. After the production of the fused protein pairs ( $\beta$ -galactosidase-A and  $\beta$ -galactosidase-B), the methionine residue was cleaved with cyanogen bromide liberating pure insulin chains. This highly refined technology made a breakthrough in having only two chains of insulin and overcoming the problem of processing of insulin precursor.

The further task was to establish a disulphide bond in between the two chains and to reconstruct them into a mature insulin. [*In vivo*, the proinsulin (with a B-chain-peptide C-A chain structure) folds and forms two disulphide bonds between A and B chains. Later, the connecting peptide C is excised to give rise to a mature insulin leaving the chains connected by disulphide bond]. However, as the two chains were scattered far apart from each

other, the chance of disulphide bond formation was less and depended on the concentration and sudden collision of the chains.

A suggestion in this regard has very recently come from M. J. Gait (1979) of MRC Laboratory of Molecular Biology, Cambridge (England) to synthesize chemically whole proinsulin DNAs with easily excisable connecting peptide C and then to allow them for disulphide bond formation. The reason behind this is that the two chains would come closer to each other, thereby increasing the chance of bond formation. The problem of excising the connecting peptide can be overcome by intercalating the known DNA sequences (specific for some restriction endonuclease) at the two sides of the peptide C gene (following the above mentioned method of Ullrich *et al.*, l.c.). The intercalated base sequences can later be cleaved by the specific restriction endonuclease, liberating the connecting peptide. Of course, the restriction enzyme for this purpose should be chosen beyond the list of those endonucleases which cleave the A and B peptides.

Very recently, the announcement by Robert Crea and his group (1978) of the Division of Biology, City of Hope National Medical Centre, Duarte, California, of the expression of synthetic human insulin genes in *E. coli* has further brought the dream of biologists nearer to reality. They have geared up the technology of gene synthesis and have made a remarkable advancement over the methodologies of H. G. Khorana (MIT, USA) and K. Itakura for joining synthesized oligonucleotides (10-15 nucleotides long DNA). It has resulted in completing the whole task of synthesizing a DNA strand (including that for insulin) within a fraction of time (in fact, in terms of man years) compared with that required for the synthesis of 77-nucleo-

tide long tyrosine transfer RNA gene by Khorana. Crea's 'phosphotriester' synthetic technology' (a substitute for Khorana's phosphodiester technology) and rapid purification techniques with the help of Hi-P (high-performance) liquid chromatography have been the two main

factors deserving credit for greatly reducing the expensive task for commercial production of insulin.

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## Uracil in DNA

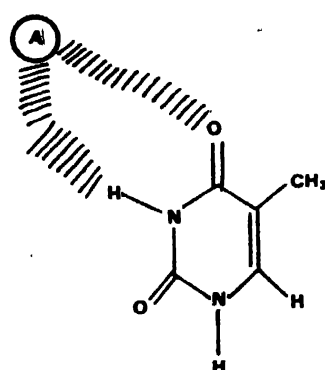
**I**N almost all text books on biochemistry, genetics and related subjects it is mentioned that deoxyribonucleic acid (DNA) contains two types of bases: purines, adenine (A) and guanine (G); and pyrimidines, thymine (T) and cytosine (C) and ribonucleic acid (RNA) also contains two types of bases: purines, adenine (A) and guanine (G); and pyrimidines, uracil (U) and cytosine (C). However there are some differences too: (1) DNA contains deoxyribose sugar moiety whereas RNA contains ribose (Fig. 1), hence the name; (2) RNA contains a pyrimidine base uracil (U) in place of closely related other pyrimidine base thymine (T) in DNA; other purines and pyrimidine bases being same in both DNA and RNA; and (3) RNA is mostly a single stranded molecule whereas DNA is generally double stranded. In spite of these differences both DNA and RNA have the ability to form double helical structures, like the two complementary strands of DNA are able to do, when allowed to come together. Neither the additional hydroxyl group nor the absence of the methyl group found in thymine (Fig. 1) affects RNA's ability to form double-helical structures held together by hydrogen bonded base pairs.

But not given in the books is an answer to the question why DNA

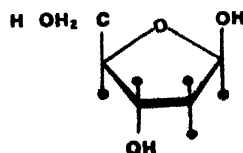
does not contain uracil?

It is not that the uracil molecules are only available for RNA from the existing pool in the cell but are equally for DNA. Specifically, an enzyme called cytosine deaminase is engaged in converting the cytosine molecules of DNA into uracil by removing the amino group of the former (Fig. 2).

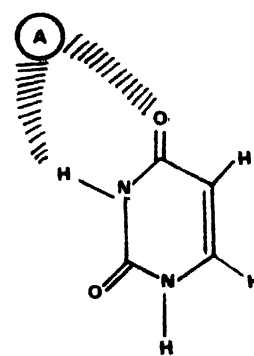
It has been experimentally observed that replacement of uracil in place of thymine in DNA molecule reduces the thermal stability of the molecule because uracil bases do not stack as effectively as the thymine bases do with the complementary bases A. But that is not very important. According to Huber Warner and Bruce Duncan of the University of Minnesota, U.S.A., "the wide range of thermal stabilities of DNA in various organisms suggests that the thermal stability of the DNA is not biologically significant" (*Nature*, 272; 32) and also under some specified conditions, they were in a position to produce biologically active T4 bacteriophage in which 30% replacement of thymine by uracil could be tolerated. This T4 bacteriophage, designated as T4:U, was viable and could replicate and reproduce well to give rise to viable progeny. But why not then DNA contains U?



THYMINE

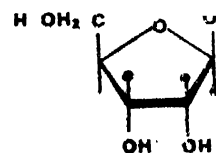


DNA



URACIL

(ABSENCE OF A METHYL GROUP)



RNA

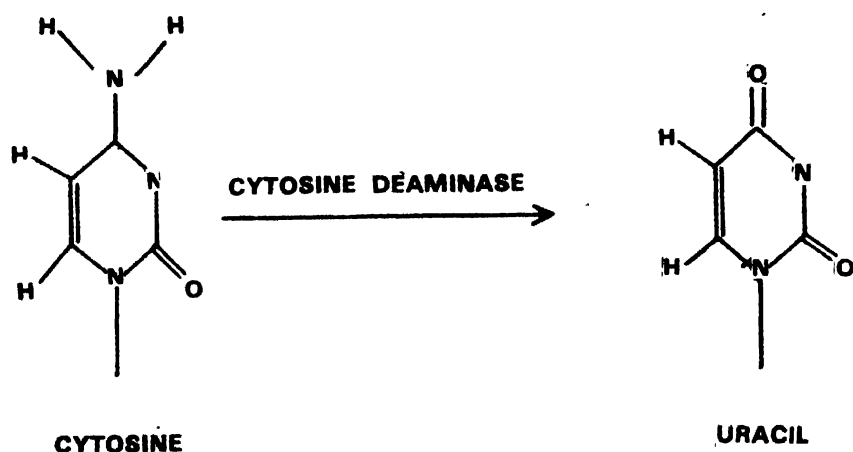


Fig. 2. Cytosine deaminase activity

Under normal conditions, the incorporation of uracil in DNA is inhibited and if somehow any uracil is already present in the DNA molecule, it is removed to give an overall picture that DNA do not contain uracil at all. Inhibition and removal of U are the two separate processes executed by two separate enzymes : the dUTPase and the uracil-DNA glycosidase, respectively. The role of dUTPase is to keep the dUTP (deoxyuridine triphosphate) pool low by hydroxlysing or converting it into (dUMP deoxyuridine monophosphate) so that the availability of the desired triphosphates is reduced; monophosphates as such, it is well-known, cannot participate in the nucleic acid biosynthesis but triphosphates do readily. The dUMP pool that results from the dUTPase activity acts, in turn, as substrate for the formation of dTTP (deoxythymidine triphosphate) with the help of another enzyme known as thymidylate synthetase thereby making T readily available to DNA, but at the expense of uracil. The role of the second enzyme,

the uracil-DNA glycosidase, is to remove specifically those uracil molecules which are already present in either single or double stranded DNA molecules. So, if these two uracil 'killing' enzymes are present in any system, no DNA could contain uracil. Conversely if these are absent, DNA may have uracil.

S.J. Hochauser and B. Weiss of the Johns Hopkins University, USA, in 1976 isolated some such viable *Escherichia coli* mutants which have no activity of dUTPase (the *dut*<sup>-</sup> mutants). These mutants cannot change dUTP into dUMP and therefore, can allow incorporation of labelled uracil into DNA. But according to Lindhal (1976) the incorporated uracil gets "repaired" almost immediately because of the activity of uracil-DNA glycosidase. Duncan and his colleagues of the University of Minnesota, USA, on the other hand, were successful in 1976 in isolating some viable *E. coli* mutants which had no uracil-DNA glycosidase activity (*ung*<sup>-</sup> mutants). But, as expected, this mutant also could not incorporate uracil because

of the activity of the other "killer" enzyme. So, if any uracil is to be incorporated into DNA, the activity of both of these enzymes should not be there.

Warner and Duncan have very recently succeeded in isolating such *E. coli* double mutants. These were designated as *dut*<sup>-</sup> *ung*<sup>-</sup> double mutants against the normal *dut*<sup>+</sup> *ung*<sup>+</sup> individuals. In order to study the extent of U incorporation, both the wild-type (which cannot take up U) and mutated (which can take up U) T4 phage particles were grown in *dug*<sup>+</sup> *ung*<sup>+</sup> and the *dut*<sup>-</sup> *ung*<sup>-</sup> *E. coli* mutants in presence of labelled uridine and then analysis was done of the T4 progeny to determine the amount of radioactivity. They concluded that whereas no uracil is found in T4 DNA in *dut*<sup>+</sup> *ung*<sup>+</sup> *E. coli* but it is indeed found in T4 DNA progeny multiplied in the *dug*<sup>-</sup> *ung*<sup>-</sup> and "about 30% of the thymine has been replaced by uracil in this (T4) DNA" (*Nature*, 272, 32). The progeny of the uracil containing T4 phage (T4:U) was functioning reasonably well showing thereby that the presence of 30% uracil in the DNA can be tolerated by the cell machinery during replication and transcription. Another recent study also indicates that the level of 1 uracil per 100 nucleotides can be tolerated in *E. coli* mutants and the uracil persists in the cell for quite a number of generations. If these two studies of uracil incorporation in T4 and *E. coli* are considered together, these "strongly suggest that uracil incorporation into DNA is a common phenomenon" (O' Donovan, *Nature*, 272, 582).

It has been suggested that actually



Fig. 3. The role of dUTPase

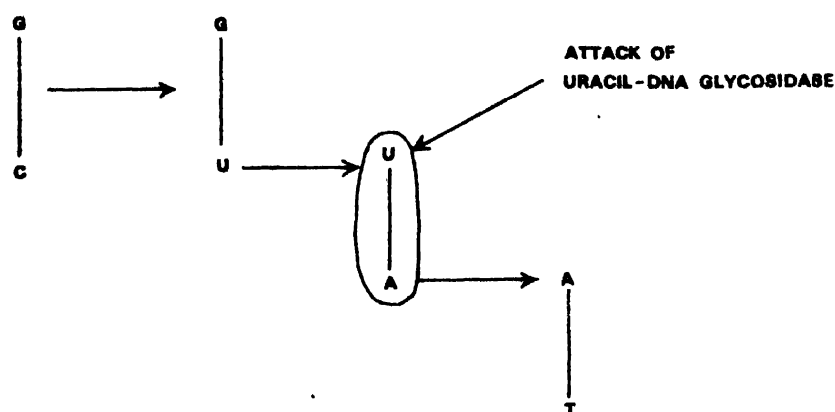


Fig. 4. Path of transition mutation from G : C to A : T and possible site for the attack of uracil-DNA glycosidase enzyme

removed from the DNA molecule and not the replacements giving an overall picture that DNA do not contain U at all.

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the role of the enzyme uracil-DNA glycosidase is to preferably attack only those uracil molecules which are formed as a result of *in situ* transitions of cytosine to uracil by removing the amino group from the former by the action of an cytosine deaminase. Cytosine deaminase however does not affect the occasional replacements of U in place of T as these replacements do not have serious consequences. The proposed path of transition mutation is  $G:C \rightarrow G:U \rightarrow A:U \rightarrow A:T$ . The uracil-DNA glycosidase attacks the A:U base pairs in preference to G:U pairs and helps A to find its normal partner T and thus forms more number of A:T base pairs. The presence of large number of A:T base pairs in DNA helps effective excision and repair of potentially mutagenic G:U mismatches produced by cytosine deamination. "The most critical role of uracil-DNA glycosidase *in vivo* may be to prevent transition mutations caused by deamination of uracil in DNA; the presence of A:T base pairs rather than A:U base pairs in DNA permits specific recognition and repair of potentially mutagenic G-U mismatches produced by cytosine deamination" (Warner and Duncan, *Nature*, 272, 32). So the enzyme uracil-DNA glycosidase acts as a "defence" against the potential lethal *in situ* transition mutations which could be harmful to the organism if U molecules are not

## A new hormone-like substance—endorphin

THE term hormone is defined as the substance secreted by the endocrine gland directly into the blood stream and acting at a site different from its origin. With the advent of new microtechniques of detection and determination, a large number of substances qualifying for hormones have been identified from non-endocrine organs such as stomach, intestine, kidney, etc.; and, for distinction, have been categorised as parahormones or autacoids. To the list has been added a new substance called endorphin.

The name endorphin was coined by Eric J. Simon of Department of Medicine, New York University Medical Centre, New York, U.S.A. from the prefix 'Endo' signifying endogenous and 'orphin' indicating its opioid activity. So the word endorphin conveys that it is an endogenous substance with opioid activity. The discovery of endorphin bears its inheritance from the isolation and characterisation of a polypeptide called  $\beta$ -lipotropin discovered by Choh Hao Li of Hormone Research Laboratory, University of

California, U. S. A. in 1964. This polypeptide was isolated from sheep pituitary and was shown to have a sequence of 91 residues of amino acids. It possessed lipolytic activity in several systems but not morphinomimetic activity. However, fragments of  $\beta$ -lipotropin were shown to possess morphinomimetic activity in the same system. This initiated an impetus for isolation and characterisation of newer morphinomimetic polypeptides from the pituitary and the brain of several species of animals.

Roger Guillemin of the Salk Institute of California, U.S.A. isolated two opiate-like peptides from pig posterior pituitary and hypothalamic extracts in 1976 and termed them as alpha and gamma endorphin. Further investigations revealed that alpha and gamma endorphin had amino acid sequence identical to the sequence of  $\beta$ -lipotropin from 61 to 76 and 61 to 77 respectively. In the same year, Choh Hao Li and David Chung of Hormone Research Laboratory, California, U.S.A., during the course of isolation of melanotropins from camel

Alfa endorphin	H-Tyr-Gly-Gly-Phe-Met-Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-OH
Gamma endorphin	H-Tyr-Gly-Gly-Phe-Met-Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-Leu-OH
Beta endorphin	H-Tyr-Gly-Gly-Phe-Met-Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-Leu-Phe-Lys-Asn-Ala-Ile-Ile-Lys-Asn-Ala-His-Lys-Lys-Gly-Gln-OH

Fig. 1

pituitary glands obtained an untriantapeptide that had an amino acid sequence identical to COOH-terminal 31 residues of  $\beta$ -lipotropin. These workers designated this peptide as beta-endorphin. Now, the endorphins have been extracted from the pituitaries of several species of animals such as rat, pig, cattle, sheep and human. Further, it is found, that the concentration (per unit of tissue wt.) is about 8 times higher in the posterior pituitary than in anterior pituitary, thus the total activity is about equal in the two lobes. The sequence of amino acid residues of three types of endorphin was characterised as shown in Fig. 1.

In addition to these endorphins, two short chain polypeptides were also isolated from pig brain by J Hughes, and his coworkers of Marischal College, Unit Research Addict Drugs, Aberdeen, Scotland in 1975. They called them Met<sup>5</sup>-enkephalin and Leu<sup>5</sup>-enkephalin. These peptides possessed morphine-like activity and had an amino acid sequence common to 61 to 65 that of  $\beta$ -lipotropin and is identical to the NH<sub>2</sub>-terminal sequence of the untriantapeptide reported by C. H. Li. The structure of Met-enkephalin was reported to be H-Tyr-Gly-Gly-Phe-Met-OH and that of Leu-enkephalin as H-Tyr-Gly-Gly-Phe-Leu-OH. However, it is doubtful if the enkephalins are the natural products. It is likely that these pentapeptides might be the degradation products or even artifacts of the isolation procedures.

Thus existence of enkephalins as independent hormone playing a vulnerable physiological role is yet to be established.

The importance and physiological role of endorphin has not been well understood. Besides morphinomimetic activity, endorphins have been shown to play a role in modulating pain and thermoregulation. Endorphins probably also play

some role in the control of effective states and also of appetitive drives (food, water, sex) known to be associated with limbic system function. Presumably, they might be acting as neurotransmitters. Recently, endorphins have been shown to be potent stimulants for growth hormone and prolactin release when injected appropriately into the brain. However, this activity has not been demonstrated *in vitro*. With the keen interest being evinced by the researchers, it can be presumed that the functions of this hormone will be well defined and this oligopeptide may find a place on physicians' prescription as a panacea for dubious ailments.

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## Biochemical basis of yield stability

THE ability of a crop variety to give stable yields over a wide range of agroclimatic conditions is a highly desirable trait. Some of the popular old crop varieties like M-35-1 sorghum, Lakshmi cotton or Spanish Improved groundnut owed their wide geographic distribution to their adaptability, which enabled them to give stable yields under a relatively wide range of agroclimatic conditions. These varieties were not only tolerant to drought and diseases, but were also adapted to poor agronomic conditions. They could give some yield even under unfavourable conditions. However these traditional old varieties had one drawback. They were inherently low yielding.

Breeding for high yield became a necessity in the late fifties because of urgent need to supply an ever-growing population with agricultural products. Development of short statured varieties of wheat and rice was first step in this direction. Both these cereal types required high levels of fertilizers, high seed rates and, most important of all, they needed irrigation. In short, the new high yielding varieties of rice and wheat needed good agronomic management and a high level of inputs. In a state like Punjab, where almost 80% of the agricultural land is irrigated, the entire state could switch from old wheat varieties to new ones, ushering into that state the "green revolution". But in rest of the coun-

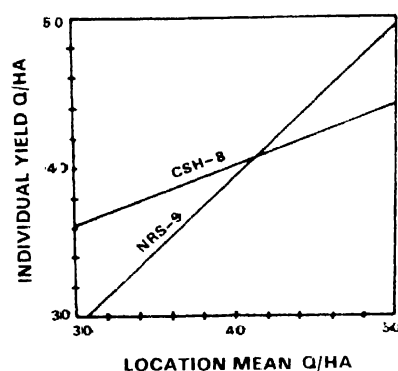


Fig. 1. Yield of CSH-8 (hybrid) and NRS-9 (inbred) sorghum in relation to the quality of the environment

try, where dry farming is still the predominant mode of agriculture, introduction of the "wonder varieties" of wheat and rice gave rise to a disturbing new imbalance in rural economy.

Because the new high yielding varieties required high levels of fertilizer inputs, good agronomic management and adequate irrigation, they could be grown successfully only by the well-to-do farmers. There is no doubt whatsoever, that the high yielding wheat and rice varieties made the country self-sufficient in food, but we cannot ignore the fact that these varieties made the rich richer, while the poor were bypassed by the new rural prosperity.

Apart from being a cause of rural economic imbalance, the new varieties also caused concern to planners because of instability of their performance. High yielding wheat varieties require regular irrigation, at least once every three weeks. Shortages of diesel and electricity have seriously disturbed irrigation schedules in the recent past to cause an appreciable fall in the national production. Another factor, recently brought to the notice of wheat farmers was that the dwarf wheats required a colder temperature than traditional tall wheats. Exceptionally warm weather during tillering phase of wheat caused yield losses consecutively for three years from 1977 to 1979 in Maharashtra.

High yielding varieties are thus finely tuned and delicate systems, which need just the right conditions for best performance. If they do not receive care and right amount of inputs, they show a drastic fall in yield.

Extremely high yields under a high level of management would be preferred by farmers who can afford to provide necessary care and inputs. But from the point of view of the average dryland farmer and national economy, somewhat lower yield potential, with stable performance under varying conditions, would be more desirable.

As a textbook adage, Indian plant breeders already knew that hybrids generally showed greater adaptability to different environments than inbred varieties. Validity of this observation was proved in the Indian context only after the introduction of hybrid crops. As an example of a hybrid crop showing greater yield stability than an inbred variety, we may mention a sorghum variety trial conducted by us in winter 1978-79. This trial included 10 sorghum varieties and it was repeated at 12 different locations. Fig. 1 shows yields of two of the entries in relation to the location mean yield. CSH-8 is a released hybrid while NRS-9 is a high yielding inbred variety. Since agroclimatic and soil factors varied from location to location, the mean yield of all the 10 varieties at any given location can be taken to be an indicator of the quality of the environment. The location mean yield improves as the environment becomes favourable and declines as the environment becomes unfavourable. The steep slope of the line representing NRS-9 shows that its yield is strongly influenced by the environment, while the gentle slope of the line representing the yield of CSH-8 indicates that its yielding ability is not affected much by environmental factors. Plant breeders tried to explain the wider adaptability

of a hybrid by the fact, that because a hybrid inherits genes from two diverse parental lines, it represents a more buffered biological system than an inbred line. But until recently they were at a loss to explain exactly how does the buffering occur.

Recent advances in our understanding of the action of genes and biochemistry have shown that the stability of performance of a hybrid has a definite biochemical basis. It is a well known fact that all biochemical reactions are catalysed by proteinous catalysts called enzymes. Although, for the sake of convenience one assumes the presence of a single enzyme for any given reaction, plants actually possess several enzymes for this purpose. These enzymes differ from one another in their physicochemical properties and can therefore be separated from each other by means of special techniques like gel-electrophoresis. Such enzymes, which catalyse one and the same reaction, but

Table 1. Activity of polyphenoloxidase in the leaves of three safflower hybrids and their parents

Pedigree	Extraction value
199920 EC 32012	0.11
199920	0.01
EC 32012	0.05
NS-133 199935 C	0.20
NS-133	0.02
199935 C	0.10
B 8 5-5 N 62-8	0.19
B 8 5-5	0.02
N 62-8	0.01

(Oxidation causes phenolic compounds to assume a darker colour. Data in the table show light extinction values of a catechol solution at wavelength 420 nm, 30 min after the enzyme extract of the test plants was added to it. Higher extinction values represent higher enzyme activity.)

which are different physicochemical entities, are termed isoenzymes. If different isoenzymes are brought together, they show an enhanced enzymic activity, a phenomenon also called isoenzyme complementation. Such a complementation can occur not only *in vitro* but also *in vivo* when different isoenzymes belonging to different parents are brought together in the cells of a hybrid organism, following the simple laws of inheritance. Data presented in Table I, which shows the activity of the enzyme polyphenoloxidase in the case of three safflower hybrids and their respective parents, clearly indicates that the enzyme activity shown by hybrids is greater than that of their parents.

But an increased activity level is not the only phenomenon that occurs when isoenzymes of diverse origin are brought together. The fact has already been mentioned that although isoenzymes catalyse one and the same reaction, they differ from each other in their physicochemical properties. As a result of these differences, they also differ from each other in their sensitivity to external factors like temperature, light intensity, pH of substrate, etc. Therefore, when isoenzymes of diverse physicochemical properties come together to form an enzyme system, they not only show a higher activity level, but also a higher tolerance to a wide range of environmental factors. It is this buffering at the enzymic level, which is supposed to make a hybrid physiologically more capable of functioning efficiently under varying environments than an inbred variety.

Conclusive proof is still lacking to support the assumption that the performance stability of a hybrid is entirely due to the phenomenon of isoenzyme complementation and the resulting tolerance of the enzyme systems to a wider range of environ-

ments. There is, however, enough evidence to show a strong correlation between the performance of enzyme systems and the performance of a plant under field conditions. Taking a clue from these findings, several research centres all over the world have started work on the feasibility of predicting the yielding ability and performance stability of varieties and hybrids on the basis of simple

laboratory tests. If these techniques are properly developed it may soon become possible to replace the costly and time consuming field trials of crop varieties and hybrids by a set of quick laboratory tests.

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## Plant polytene chromosomes

**T**HE great genetic discoveries which have resulted from the thorough study of salivary gland chromosomes (giant chromosomes or polytene chromosomes) in the larvae of *Drosophila* and other dipteran insects have stimulated investigation of large chromosomes in other forms of life. In 1962 plant polytene chromosomes were demonstrated by W. Nagl of the Institute of Botany, University of Vienna (presently attached to the Department of Biology, The University, Kaiserslautern, FRG) in the giant basal cells of the suspensors of the embryo of *Phaseolus coccineus* (runner bean). Such structures in suspensors have already been observed (though not realized) by Bianchi (1946) in *Llodia serotina* and were later found in two *Helobia* by Hasitschka-Jenschke (1955; vide Zeit. Schrift für Pflanzenphysiologie, 73, p. 2, 1974) who compared them with salivary gland chromosomes of dipteran flies.

The suspensor is a short-lived organ which develops prematurely but whose cells are not involved in the formation of the seedling. It is attached only to the early proem-

bryo which later forms the entire post-embryonic plant (Fig. 1). An interesting feature of the suspensor of many plant species is that cells cease mitosis early and differentiate through endopolyploidization to large cells that connect the embryo to the maternal seed wall.

Further investigations have shown that the polytenic nuclei could be seen in other parts of the plant body. H. V. Ivanovskaya of Biological Faculty of Moscow State University (1973) reported various functional structures in the giant chromosomes occurring in wheat antipodal cells. Similarly, Nagl (1976) also reported polytenic nuclei in antipodal cells in *Scilla biflora*. Another interesting

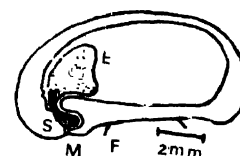


Fig. 1. Diagrammatic presentation of a median longitudinal section through an ovule of *Phaseolus coccineus*; E-embryo with growing cotyledons, F-funiculus, M-micropyle, S-suspensor (From W. Nagl, 1974)

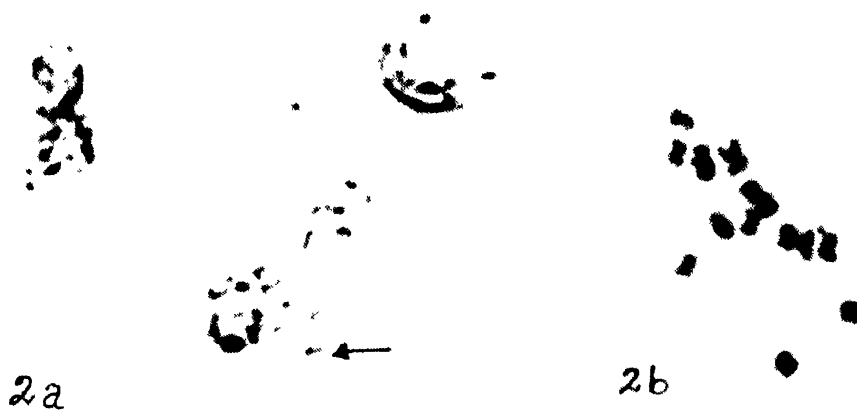


Fig. 2.(a) Three polytene chromosomes of *Phaseolus vulgaris* found in the endopolyploid cells adjacent to the root tip meristem. One diploid chromosome (arrowed) is lying beside on polytene chromosome (From Bhattacharya, 1978). (b) Diploid chromosomes in the root meristem of *Ph. vulgaris*.

report by the present author (Bhattacharya, *Cytologia*, **43**, 631-637, 1978, *Curr. Sci.*, **48**, 635-637, 1977) is the presence of polytenic chromosomes in the endopolyploid cells adjacent to the root tip meristem of *Phaseolus vulgaris* (French bean), *Ph. aureus* (Mung), *Ajuga genevensis* (a weed belonging to the family Labiatea) (Figs. 2a, 2b, 2c).

Polytene or giant chromosomes are bundles of stretched interphase chromosomes which originate by increase

in transversal multiplicity as a result of endomitotic cell cycles or endoreduplication cycles without separation of the produced sister chromosomes (or endochromosomes). The type of cell cycles allowing the formation of polytene chromosomes are shown in Fig. 3. The length of the giant chromosomes is 15 to 30 times greater compared to that of the diploid chromosomes. Both the length and the diameter of the giant chromosomes depend on the degree of endopolyploidy, the functional state and somewhat on the artificial stretching during preparation. Level of

polyploidy of these endopolyploidy cells were found to be as high as  $c192n$  compared to  $2n$  (Nagl, 1974).

Plant polytene chromosomes appear to be usually unpaired and therefore, occur in the diploid number. In antipodal cells they are found in the haploid number (Nagl, 1974). Plant polytene chromosomes are not showing regular bands and interbands as found in dipteran polytene chromosomes at ordinary temperature (Fig. 2a). However, puffs (functional units) are reported (Nagl, 1969; Bhattacharya, 1978). Bands

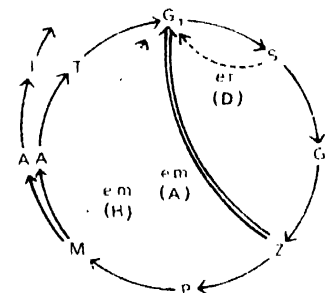


Fig. 3. Diagram of the mitotic cell cycle, and its alteration (short-cut) in the course of endoreduplication and endomitosis (From Nagl, 1974).

appear after special treatment (Fig. 4). The euchromatic portions of the polytene chromosomes normally exhibit a granular chromomere



Fig. 2(c). Endopolyploid cells (the largest ones) found adjacent to the root meristem. One is prominent with polytene chromosomes (arrowed) (Bhattacharya, 1979).



Fig. 4. Five polytene chromosomes after 48 hour cold treatment stained with orcein showing dark and light bands and interbands (Bhattacharya, 1978).



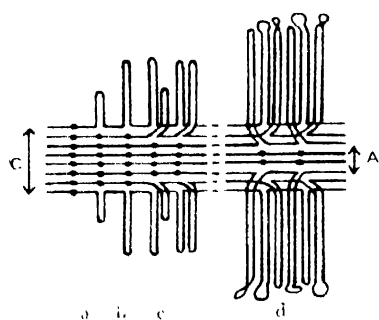


Fig. 5. Schematic drawing of the development of the lampbrush state as suggested by Nagl (1970)

structure with some heterochromatic blocks and bands (Figs 2a and 4). A unique feature of the giant chromosomes of *Ph. coarctatus* is the occurrence of a lampbrush state which takes place under certain environmental stimuli (Fig 5, Nagl, 1970)

DNA replication pattern of the polytene chromosomes could be seen within 2-4 hours for the whole length (Nagl, 1976, Bhattacharya, 1978) whereas in metaphase chromosomes 6-12 hours are required for the same purpose. Avanzi *et al* (Institute of Botany, University of Pisa, Italy, 1972) have shown the loci of ribosomal cistrons, i.e., rDNA (which is responsible for ribosomal RNA) in the nucleolus-organising region of polytene chromosome pairs No. 1 and 5 in *Ph. coarctatus* and in the proximal heterochromatic segment of the long arm of chromosome pair No. 1 as well as in the terminal heterochromatin of chromosome pair No. 2. Similar results were found by Brady and Clutter (*J. Cell Biol.*, **53**, 827, 1972) in polytene chromosomes of *Ph. vulgaris* and *Ph. coarctatus* with radioactive rRNA from germinated seeds of *Ph. vulgaris*.

The activities of polytene chromosomes are DNA synthesis, RNA synthesis and production of micronucleoli. The significance of endopolyploidy and polyteny lies possibly in protein synthesis in short-lived, but highly specialized cells.

Obviously, the study of plant polytene chromosomes like dipteran polytene chromosomes has opened new vistas to the plant geneticists and holds good promise of further

research.

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## Solubilisation and its applications

MANY substances, that are in soluble or very sparingly soluble in a solvent, dissolve to a considerably greater extent in presence of very small amount of surfactants. The increased solubility of the compound in the presence of a surfactant is called solubilization. The phenomenon is utilized in many pharmaceutical, industrial and biological processes which cover wide area of application.

In a solvent, like water, surfactant molecules associate to form particles of colloidal dimensions called micelles. The structure of micelles is such that the hydrophobic (water repellent) ends remain close together whereas the hydrophilic polar head groups dissolve in water. The substance to be solubilized, e.g., benzene, being hydrophobic in nature gets attached to the hydrophobic end of the micelles. Several factors such as nature of surfactant, temperature, electrolytes and others which favour micelle formation influence solubilization.

Solubilization is different from emulsification; in the former process thermodynamically stable solution is formed. Insoluble substances may also be solubilized in water by addition of fairly high concentration of some substances like sodium benzoate or sodium salicylate which do not form micelle. The phenomenon is called hydrotropy and is different from micellar solubilization.

There are many pharmaceutical substances which have only a limited

solubility in water. This presents formidable problems to formulators of acceptable doses. The use of solubilizers increases the solubility of sparingly soluble drugs and has been widely used in pharmacy.

Before the advent of commercial surfactants, a common method of increasing the solubility of drugs was to employ a two-component solvent system or a hydrotropic agent (a substance that increases the miscibility of two liquids or a liquid and a solid). But the use of alcohol-water mixture, for example, is limited and hydrotropic compounds are usually effective in high concentration which places a restriction on their use. With the large-scale introduction of surface-active agents and the discovery of the phenomenon of micellar solubilization, its pharmaceutical applications soon became obvious. Water insoluble bactericides, vitamins, steroids, essential oils, antibiotics, dyes, etc., can now be solubilized for easier application in medicinal preparations. (Some drugs themselves form micelles and behave like surfactants). Many steroid hormones have low aqueous solubility but can be solubilized in presence of surfactant proteins and bile salts. A concentrated solution of sex hormones and their derivatives can be prepared in bile acids and their salts. Water insoluble vitamins (A, D, E and K) can also be solubilized in surfactant solutions.

Solubilization is utilized in many

industrial processes. The processes of emulsion polymerization, detergency, dyeing and repainting, etc., are associated with solubilization. The preparation of perfumery products and the formulation of cosmetic materials, and herbicides in surfactant solutions are of great significance.

Because of their multifarious effects on the physical properties of solutions, surface active agents in many cases have pronounced effects on the biological activity of drugs in contact with them, e.g., the hypnotic

effect of chloral hydrate is enhanced by polysorbate—a non-ionic surfactant. Many non-ionic surfactant solubilized preservatives, antibacterial and antifungal agents are used in hair shampoos and skin cleansing agents. Essential oils from plants can be isolated by solubilizing the oil with an acid surfactant and then liberating it from solution by the addition of an electrolyte.

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## Food poisoning by the fungus *Fusarium*

**S**POILAGE of food and food crops by fungi and diseases caused by consumption of mouldy foods (mycotoxicoses) are serious problems particularly in developing countries where climate is moist and warm. These factors facilitate fungal growth. Mouldy food should normally be destroyed but in adverse economic or social situation it may have to be consumed of necessity. Fungi grow on and within the food. During growth they may produce their own toxins (mycotoxins) or chemically transform normally harmless compounds in the substrate into poisonous ones. Mycotoxicoses have distinctive characteristics. The disease is not transmissible. Drugs and antibiotics have little effect. Field outbreaks often occur seasonally or are linked to certain climatic conditions. Mycotoxicoses are of great significance in the health of animals. Components of many feeds prepared on the farm or manufactured commercially are heavily infected by fungi capable of producing toxins. Although many species of fungi common in feeds can produce potent toxins, those produced by

the fungus *Fusarium* have received wide attention because of its greater incidence and importance than any other mycotoxins.

A number of reports on toxicoses both in humans and animals ingesting grains infected by *Fusarium* have appeared in Japanese literature. Toxicity occurrence in humans in Tokyo in 1946 and Hokkaido in 1949-50 were attributed to contamination by *Fusarium* isolated from wheat samples.

Alimentary toxic aleukia or septic angina which is characterized by fever; hemorrhagic rash, bleeding from nose, throat, gums, sepsis, exhaustion of bone marrow has been recorded in Russia since 19th century. In 1932, the disease reappeared suddenly in endemic form in several districts of Siberia. Mortality rate was high and whole families or even entire villages were affected, mostly in agricultural areas. In 1944, populations in Orenburg and other districts of Russia suffered enormous casualties; more than ten per cent being affected. The cause of the disease was reported as food toxicity by the fungus *Fusarium*.

Since 1919, a recurring problem for hog feeders in the United States has been *Fusarium* infected grains, exacerbated in 1971 by an unusual cool and wet year. *Fusarium* contaminated grains when fed to swine or animals cause either refusal or vomiting.

Although toxicological research on *Fusarium* has been carried out by several investigators, isolation and characterization of only a few toxins has been successful. Of them zearalenone (E-2 toxin) and tricothecene derivatives (T-2 toxin, diacetoxyscirpenol, vomitoxin) pose tremendous health hazard.

Zearalenone is known to cause severe genital disorder in dairy cattle (*Microbial toxins*, 1971, vol. 7, Academic Press). *Appl. Microbiol.* 1970, 20, 31). Estrogenism was first reported by Buxton in certain herds in Iowa (*Vet. Med.*, 1927, 22, 451). The estrogenic syndrome in swine, where the association of estrogenism and *Fusarium* was first made, involves primarily the genital system, in the prepubertal gilt, the vulva becomes swollen, the uterus is enlarged and tortuous, the ovaries are shrunken and pregnant swine may abort. Young males may undergo feminizing effect with the atrophy of testes and enlargement of mammary glands.

T-2 toxin causes necrosis and hemorrhage in liver, stomach and other organs (*Appl. Microbiol.*, 1973, 24, 540). Intestines and abdominal cavities of affected pigs often contain blood. Fescue foot disease of cattle is also caused by T-2 toxin. In Fescue foot disease animals become lame in the hind quarter. Some of these animals become very lean and thin with rough hair coat and develop cracks at the junction of hoof and skin on their hind legs. Though several of the cows give birth to normal calves, they cannot provide adequate milk to keep them alive. The toxin brings about a reduction of blood flow to the extremities of

grazing animals. In cold weather, this results in dry gangrene and eventually sloughing of affected limbs, tails and ears. Sporadic outbreaks of mouldy corn poisoning of equines, chiefly donkeys, in Egypt have been traced to *Fusarium moniliforme* (*Am. J. Vet. Res.*, 1968, **29**, 2029). Symptoms indicate neurological disorder and extensive brain lesions.

Diacetoxyscirpenol causes dermal toxicity in small and death in high doses (*Appl. Microbiol.* 1977, **21**, 1029) whereas vomitotoxin is responsible for emesis and feed refusal.

Growth of *Fusarium* on grains requires a high moisture content (20% to 22%), temperature may also be critical and may determine which toxic trichothecene will be produced. For example, T-2 toxin is produced at a lower temperature (8°C) in contrast trichothecenes such as fusarenone A and vomitotoxin which require higher temperature (25°C to 27°C).

So far there is no report of any established *Fusarium* toxicoses in India either in animals or in humans. Recently mycotoxin pollution of some foodstuffs has been reported from India. From the seeds of sunflower (an important oilseed crop) infected with *Fusarium* species, three toxic compounds diacetoxyscirpenol, T-2 toxin, 12, 13, epoxytrichothecenes have been isolated in quantities sufficient to cause mycotoxicoses on prolonged ingestion (*Experientia* 1977 **33**, 574). The presence of mycotoxins has also been reported from mouldy sweet corn growing in the Ganges valley during July. Indian people consume sizeable amounts of sweet corn in semibaked form as a vegetable. Toxins are thus probably not destroyed in cooking (*J. Pharm. Sci.*, 1978, **67**, 1768). Three recognized mycotoxins, viz., zearalenone, diacetoxyscirpenol and T-2 toxin have been isolated from malformed flowers and shoots of mango plants infected with *Fusarium*

*moniliforme*. Extracts of these parts of mango are liberally used in indigenous system of medicine. Particular care should therefore be taken about the soundness of plants at the time of collection (*Phytochemistry* 1978, **17**, 689). Occurrence of T-2 toxin in *Fusarium* infested sorghum has also been reported in our country (*J. Agric. Food Chem.*, 1978, **26**, 647.) Paddy grains are fermented and parched before unhusking. During fermentation *Fusarium* species have been found to grow on the moist grains and produce vomito-

toxin and zearalenone (*Appl. environ. microbiol.*, 1978 **35**, 105). This is suggestive of possible mycotoxin occurrence in processed rice as well. In India fifty economically important crops are known to be infected by seventy-two species of *Fusarium*. Risk of mycotoxin contamination of a large variety of food and feeds is indeed very real and quite high.

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## Concrete TV towers

ALL the fifteen TV towers constructed so far in India are of steel. But steel is a costly material and the use of concrete as an alternative will be economical. Pre-stressed concrete also may be used in the construction of these towers. A large number of concrete and pre-stressed concrete towers have already been built in a number of countries. Fig. 1 shows the pre-stressed concrete TV tower at Munich (Munich) constructed specially for the 1972 Olympics.

In addition to economy, the reinforced concrete TV towers have many distinct advantages over steel towers. (1) They provide an aesthetic appearance. (2) Buckling is not serious in reinforced concrete construction. (3) Corrosion of steel structures, especially near coastal areas, requires special attention. This can be minimized in concrete towers by the use of special admixtures in concrete or by using high strength concrete; (4) Concrete struc-



Fig. 1. Concrete TV tower at Munich

tures, being massive, are less susceptible to wind and earthquake forces; (5) The inner shell in the case of a concrete TV tower may be utilised for many purposes like a revolving restaurant. (In fact, most of the concrete TV towers built in Germany and America have revolving restaurants); (6) Concrete towers are less costly to maintain than steel structures, which require considerable expenditure for painting; (7) Slip-form work for concrete tubular structures has made the construction of RC towers of any height simple, whereas welding and riveting of steel towers at such heights pose a big problem.

Even though, the speeds of construction cannot be compared and strict quality control is essential for reinforced concrete construction, the use of reinforced concrete in TV towers will result in 15 per cent to 20 per cent saving.

The advent of electronic digital computers has made analysis of these types of structure very easy. It is now possible to analyse and design these structures using the digital computers available in India. The authors have developed computer programs to run on the IBM 370/155 computer for the accurate analysis of these structures.

Concrete TV towers have already

made an impact in India and the All India Radio is constructing a 200 m high TV tower at Jullunder, about 320 km from New Delhi. Once constructed, this will be the first concrete TV tower in India. This tower consists of a 127 m high hollow concrete tapered shaft and a steel space truss structure for the upper 73 m. A viewing gallery and a restaurant have also been proposed near the top.

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## SCIENCE FOR THE YOUNG

### Answers and solutions

#### Solutions to brain teasers

1. Call the number of questions answered correctly  $x$ . So, the number of questions to which wrong answers were given is  $26 - x$ .

The total score is

$$8x - 5(26 - x)$$

This must equal zero, i.e.,  $8x - 5(26 - x) = 0$ . So  $x$  is 10. Therefore, ten questions were correctly answered.

2. Call the areas of the small and the large circles A and B respectively. If the common area of the circles be  $x$ , then the areas of the nonoverlapping portions are  $A - x$  and  $B - x$  (Fig. 3). The difference between the areas of the nonoverlapping

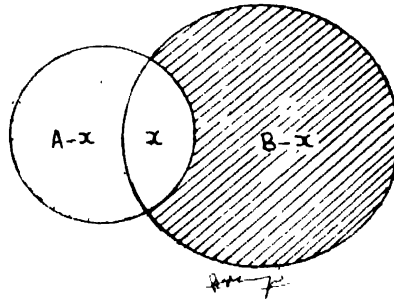


Fig. 3

portions is  $B - A$  which equals  $\pi (20)^2 - \pi (15)^2$  or  $175\pi$ . Taking the value of  $\pi$  as  $22/7$ , this works out to be 550 sq. cm.

3. See Fig. 4.

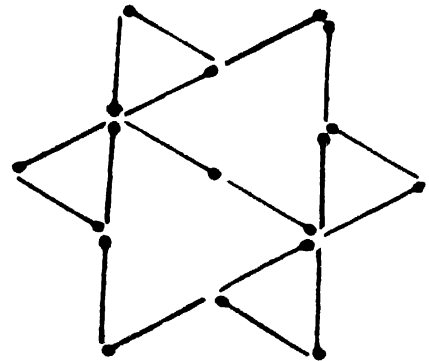


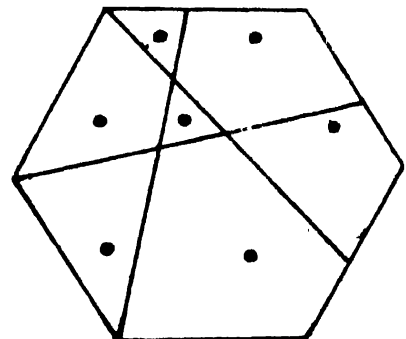
Fig. 4

#### Answers to science quiz

1. (b)    2. (d)    3. (c)    4. (c)
5. (c)    6. (b)    7. (b)    8. (c)

#### Corrigenda

1. The letter of Prof. Abdus Salam published on page 157, *S.R.*, March 1980 was dated May 4, 1965.
2. Re : *S.R.*, February, 1980, *Lichen—an idyllic consortium*, p. 114: read the authors as . B.K. Mishra, Deptt. of Botany, S.C.S. College, Puri, Dr. B. Padhi, P.G. Botany Deptt. Vani Vihar, Bhubaneswar.
3. Re . *S.R.*, March 1980, solution to Brain teasers p. 214, The correct Fig 3 is printed here.





## Forestry conference

**T**HE Second Forestry Conference was held at the Forest Research Institute and Colleges, Dehra Dun from January 16 to 19, 1980. It was attended by over 250 delegates from different parts of the country. More than 200 research papers were presented by the various State and Central Forestry Agencies, Forest Development Corporations, Universities, Indian Institute of Management, Indian Council of Agricultural Research and other research organisations. B.P. Shrivastava, Inspector General of Forests, Government of India, while inaugurating the Conference stressed the important role of forestry in combating the acute energy crisis and environmental pollution. He pleaded for faster development in forestry so as to ensure conservation and protection of the rich and varied forest wealth of India.

The 4-day Conference was divided into nine Technical Sessions: Organisation of Forestry Research and Education in India, Natural and Man-made Forests, Forest Management, Social Forestry, Forest Genetics and Tree Improvement, Forest Protection, Environmental Conservation and

Wildlife, Minor Forest Products and Energy Problems and Energy Plantations.

While initiating discussion on Forestry Research and Education, B.P. Das, Director of Forest Education, stressed the need for intensive research in forestry. He emphasised that it should be oriented on farm-like basis as in agriculture to secure early and reliable results. The second day of the Conference dealt with the problems concerning regeneration of forests and afforestation programmes. The foresters were asked to preserve ecosystem, and afforest degenerate areas. It was indicated that a major change in forest policy was needed to secure ecological balance. The Conference also discussed and concluded that the *Chipko* movement for preserving the ecosystem in the Himalayas is not baseless.

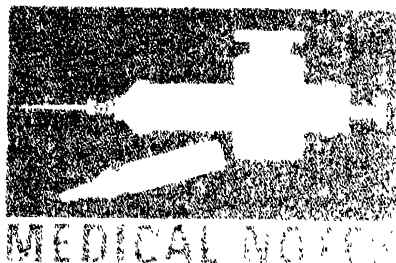
In the Technical Session of Forest Genetics and Tree Improvement, S. Kedharnath, a Fellow of Indian National Science Academy and Director of Biological Research of the Forest Research Institute, stressed the need for immediate improvement of the desirable fast-growing forestry species for solving acute fuel crisis as well as timber need of the country. The Conference discussed at great length the problems relating to natural and man-made forests which include plantation of Teak, Sal, *Eucalyptus*, Conifers, agro-forestry, afforestation of difficult sites, etc. At the beginning of this century about 37% of the country was covered with forests. At present forests occupy an area of 75 million hectares, which is approximately 23% of the total land area. The delegates cautioned that any further felling of trees or intensive conversion operation will pose a serious threat to the eco-system of nature which is

already delicate and fragile. Discussions were also held on the fast-growing plant species like *Eucalyptus*, Pines, Poplars and other exotics, which have been found to be highly productive as well as economically viable.

On the last day of the Conference the debate was largely on today's energy crisis. Oil is not a perennial source of energy. By the end of present century world's oil reserve will be finished. Forests, on the other hand, can provide the best, ever lasting and the cheapest energy source. R.C. Ghosh, Director of Forestry Research stressed that biomass in its various forms and its conversion into efficient energy fuels should replace the present use of phytomass as primary source of energy. He also advocated new studies to increase energy outputs from forest lands. A suggestion was also made for breeding plant species which convert solar energy more effectively instead of the traditional plantation. Various delegates mentioned the possibility of utilizing plant latex for its conversion into fuel oil.

The concluding session passed resolutions highlighting the afforestation programme through better management techniques and intensive research and development. The Conference will recommend to the Union and State Governments the need for a fresh appraisal of forestry problems and potentials in the changing international scene, in particular in the development of energy plantations to combat the deepening energy crisis.

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## Chelates in medicine

WITH increasing industrialisation, industrial effluents have become a major health hazard in most advanced countries. Effluents containing organic wastes pollute rivers and waterways, but they are not dangerous in the long run as they eventually get decomposed. Heavy metals such as lead, mercury, cadmium, etc., are non-biodegradable and pose serious threat to life, especially as they easily get into the food chain through aquatic organisms. Some metals such as copper, iron and zinc, in low concentrations play essential role as catalysts and as constituents of enzymes in our body. In larger quantities they are highly toxic.

In their normal physiological action, the trace metals form complexes with organic molecules known as chelating agents. The complexes, called chelates, are large molecules with five- or six-membered ring structures (Fig. 1). A number of such compounds are of biological importance. For example, haemoglobin of red blood cells and chlorophyll of green plants are chelates of iron and magnesium respectively, while vitamin B<sub>12</sub> is a chelate of cobalt. Heavy metals produce their toxic action by replacing the essential metal ion from such complexes. For example, the high toxicity of cadmium is due to its replacing zinc in the body. Zinc is essential for breakdown of

fats in the body. When it is replaced by cadmium, fat accumulates in the circulatory system leading to high blood pressure and heart disease.

The body also contains, or produces, substances such as adrenalin, cortisone and citric acid that can form chelate compounds with metals. It is generally believed that heavy metals produce their toxic effect by binding with these substances thereby preventing their normal functioning.

Physicians treat heavy metal poisoning by administering chelating agents which combine with the harmful metal ion in a way that makes the latter inaccessible to body tissues. In this form, the heavy metal is eventually excreted from the body.

To function as a chelating agent, an organic compound must have an acidic hydrogen atom, as in  $-\text{OH}$ ,  $-\text{NH}$ ,  $-\text{SH}$ , or at least one lone pair of electron, as in  $\text{N}:$ ,  $\text{O}:$ ,  $\text{S}:$ . Chelate formation takes place by coordinate covalent bonding (in which one atom

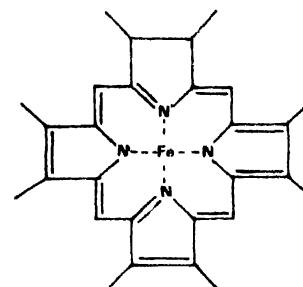


Fig. 1. A typical metal chelate of iron

in the bond contributes both the electrons that are to be shared) between the metal ion and the chelating agent. Some of the common chelating agents used in medicine are described here.

Ethylene diamine tetra-acetic acid (EDTA) and its derivatives are one of the most widely used chelating agents in research and industry. When the disodium salt of EDTA was tried as an antidote for metal poisoning, it turned out to be highly toxic as it rapidly inactivated the

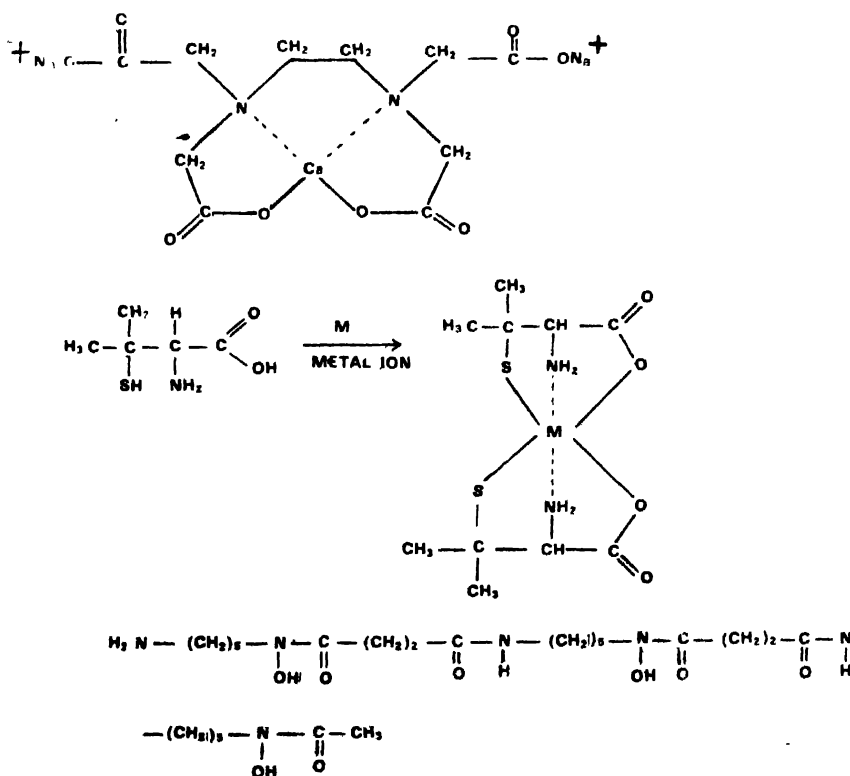


Fig. 2 CaNa<sub>2</sub> EDTA (Top); Penicillamine chelate (Middle); Desferrioxamine (Bottom)

calcium ions in the body by forming chelates. But soon it was discovered that as disodium calcium chelate (Fig. 2, *Top*), EDTA is nontoxic and can be used to treat poisoning by heavy metals. Nowadays it is mostly used to treat lead poisoning. When administered intravenously, calcium in the chelate gets replaced by lead, which has greater affinity for the EDTA molecule. The resulting lead chelate is rapidly excreted in urine. Toxic effects of excessive iron or copper due to accidental ingestion can be treated in a similar way.

2:3 dimercapto propanol, a sulphur-containing chemical commonly known as BAL (British Anti Lewisite) was originally developed to treat the toxic effects of Lewisite, an arsenical poison gas used in World War I. Today it is the most commonly used antidote for arsenic, antimony, mercury and gold poisoning. Being insoluble in water, it is dissolved in an oil base and used as intramuscular injection.

Penicillamines (Fig 2, *Middle*) are derivatives of penicillamine or dimethyl cysteine, a product obtained by hydrolysis of penicillin. They are used to treat lead, mercury, iron and copper poisoning. Although these compounds are less potent antidotes than BAL, they are more often used as they can be taken by mouth.

Iron poisoning is often seen in children who are given large doses of iron tablets. It causes gastrointestinal and liver damage. Desferrioxamine (Fig. 2, *Bottom*) is one of the most effective drugs known to chelate excess iron. It is isolated from the fungus *Streptomyces pilosus*. Desferrioxamine apparently chelates with the iron in ferritin and transferrin (storage and transportable forms of iron in the body), but not with the iron of haemoglobin. The chelate formed with the excess iron is readily excreted.

Metal chelates are also important in medical diagnosis. For X-raying certain organs such as the intestines, it is necessary to make

them opaque to X-rays by use of substances like barium meal containing a heavy metal. But barium meal cannot be used for all organs. In such cases chelates of heavy metals can be used with advantage as they

are relatively non-toxic and are easily excreted.

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## Xeroderma pigmentosum—a skin cancer caused by sunlight

IN his Notebooks, Leonardo da Vinci wrote, "The sun has substance, shape, movement, radiance, heat and generative power. I do not perceive in the whole universe a body greater and more powerful than this, and its light illumines all the celestial bodies which are distributed throughout the universe." Indeed, the importance of sun as the star responsible for continuation of life on our planet is well recognised. Ultimately, all life on earth depends directly upon the assimilation of carbon dioxide into organic compounds. The energy for this highly endergonic process is provided by the solar radiation. The reactions responsible for this complex conversion of photonic energy into chemical energy are collectively known as

photosynthesis. Furthermore, in animal tissues 7-dehydrocholesterol, which occurs in epidermal layers is converted by ultraviolet radiation of sunlight into vitamin D<sub>3</sub> which effectively prevents rickets. Not only this, nowadays possibilities are being explored to replace the conventional sources of energy by solar energy. Despite all these useful effects sunlight also causes some injurious effects such as sunburn and skin cancer in higher organism and growth inhibitions, mutations and killing in the micro-organisms. These deleterious effects are caused by the ultraviolet (1000 Å - 3800 Å) components of solar radiations.

Sun emits a vast spectrum of radiation of which visible radiation is only a tiny fraction. Solar radiation

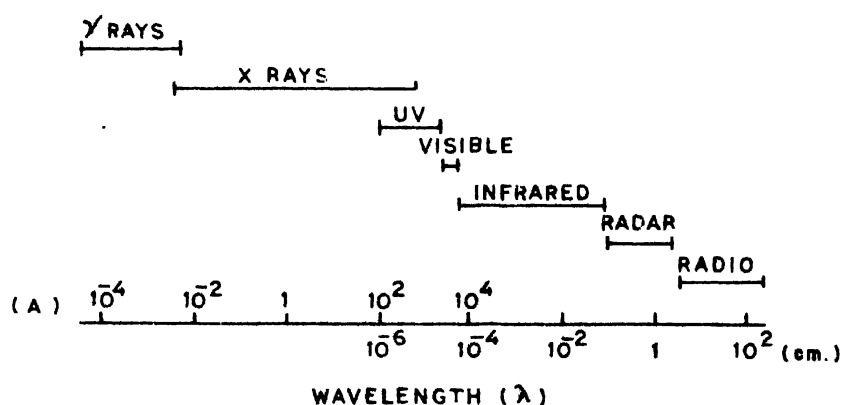


Fig. 1

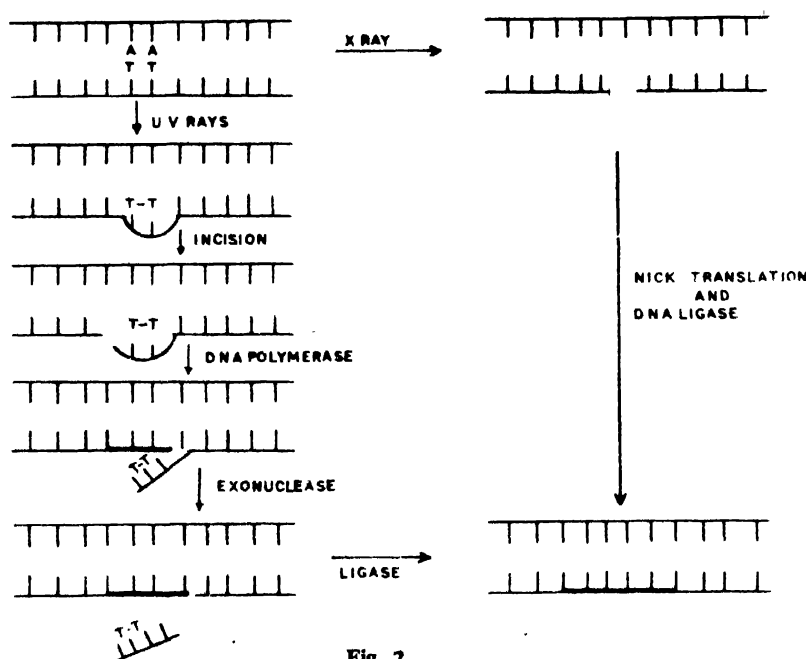


Fig. 2

includes in order of decreasing energy cosmic, gamma, X, UV, visible, infrared, radar and radio radiations. These radiations are represented in Fig 1.

The intensity of the solar radiation that reaches at a particular point on the surface of the earth, depends upon the amount of ozone, air, haze and clouds between that point and the sun. Shorter wavelength ( $< 3000\text{\AA}$ ) are effectively screened off by ozone. Both air and haze absorb UV below about  $1900\text{\AA}$ . However, it has been reported that on a bright day, an appreciable amount of far UV ( $1900\text{\AA}$  -  $3000\text{\AA}$ ) also reaches the earth's surface, which has got significant germicidal action. It is this fraction of solar radiation that induces *Xeroderma pigmentosum*, a rare hereditary cancer, in the human beings.

Ultraviolet light is strongly absorbed by the DNA and protein that leads to abnormality in these molecules. Two types of chemical changes take place in the DNA after absorbing ultraviolet light. First, covalent bonds are formed between pyrimidine residues (specially thymine) adjacent to each other in the

same strand, forming thymine dimer (Fig. 2). These dimers distort the shape of DNA molecule and interfere with normal base pairing. Second, pyrimidine residues are hydrated. Most of the lethal effects of ultraviolet light is attributable to the formation of thymine dimers. Mutations, on the other hand, can probably result from either type of chemical change.

When the human skin receives sunlight, UV component leads to the transformation of thymine dimer into cellular DNA. Normally, a DNA repair process operates in the cell. The process involves an incision on the affected strand of DNA near the thymine dimers by an endonuclease enzyme. Oligonucleotides containing the thymine dimers are removed by exonuclease activity of the enzyme DNA polymerase I. The resulting gaps are filled by the synthetic action of DNA polymerase I to which the complementary strand serves as a template. The final gap is enclosed by the DNA ligase enzyme. The whole process is represented in Fig. 2. However, the mechanism does not

operate in persons suffering from *Xeroderma pigmentosum*. These persons are unusually sensitive to solar radiations that lead to severe skin reactions and formation of skin tumors in them. It has been observed that after far-UV irradiation the skin fibroblasts (tissue culture cells) of such patients do not repair the thymine dimers formed in DNA. However, prior to far-UV irradiations if the fibroblasts are treated to X-rays, repair of the DNA occurs. It is well established that X-rays produce nick in the DNA. The nick is translated by DNA polymerase and the DNA ligase fills the gap (Fig. 2). It is postulated that X-ray radiations cause chain break and then endogenous exonuclease, polymerase and ligase activities repair the damage caused by far-UV in the patients suffering from *Xeroderma pigmentosum*. Therefore, it is evident that molecular lesion for this rare disease is the absence of an endonuclease for incision, which makes it impossible to follow the repair mechanism.

It is well established that *Xeroderma pigmentosum* is caused by the far-UV ( $1900\text{\AA}$  -  $3000\text{\AA}$ ) component of sunlight. However, it has been estimated that approximately 2% to 3% of the solar energy reaching the surface of earth is in the near-UV ( $3000\text{\AA}$  -  $3800\text{\AA}$ ) region. Not much is known about the near-UV action on the human beings. However, near-UV radiations induce growth inhibition in bacteria. Mechanism of near-UV action is not very clear, but it is postulated that near-UV uncouples the electron transport chain and oxidative phosphorylation. Therefore, energy production in the cells stops and this leads to growth inhibition. It is a temporary effect and bacteria may recover after some time.

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## Hair in crime

**L**ET us first acquaint ourselves with the structure of hair before we see how it becomes a vital clue in catching a criminal. There are two kinds of hair: real hair (we shall call it 'hair') and fuzz. Hair is generally long and stiff whereas fuzz is curly, short and, sometimes, woolly.

Hair consists broadly of three parts--root, tip and shaft (Fig. 1). Each hair is ensheathed in an epidermal pit known as hair follicle. The portion of hair that projects out from the surface is called shaft and the portion that is in the skin is called root. The root ends into a bulbous swelling within, known as the bulb of hair, which is surrounded by a soft, whitish material known as the germinal matrix. The latter is responsible for the growth of hair.

Root is not of much importance in detecting the origin of the hair, and very often it is missing on the hair found at the scene of crime. A living root can easily be distinguished from a dry and dead one. Hair with living roots clearly indicate that they have been pulled out by force and those with dry roots are indicative of natural falling.

Tips of hair may be natural or cut. The original, primitive form of the tips can be seen in hairs of women

whose hair has never been cut. The form of the cross-section of the tip varies greatly on different parts of the body. The cross-section of hair on the head is generally round (curled hair is sometimes oval). The cross-section of hair on beard and moustache is triangular in shape with

concave sides. The cross-section of hair of torso is oval or kidney-shaped. These characteristics should not be regarded as final because the appearance of the cross-section is fairly variable and on animals many varied types of cross-section can be found. They are however important in criminal investigations.

When viewed under a powerful microscope three distinct parts of the hair are observed: medulla, cortex and cuticle (Fig. 2). So far as criminal investigations are concerned medulla is of prime importance. The medulla of hair is occupied by the medullary cavity which is usually filled up with some irregular cells. The medulla can be continuous or interrupted. It is continuous in a large number of animals and very often interrupted in human beings, monkeys and horses. Diameter of the medulla may remain absolutely constant but may also at times be alternately narrower and broader in the same hair. For practical purposes diameter of medulla is of no significance, but

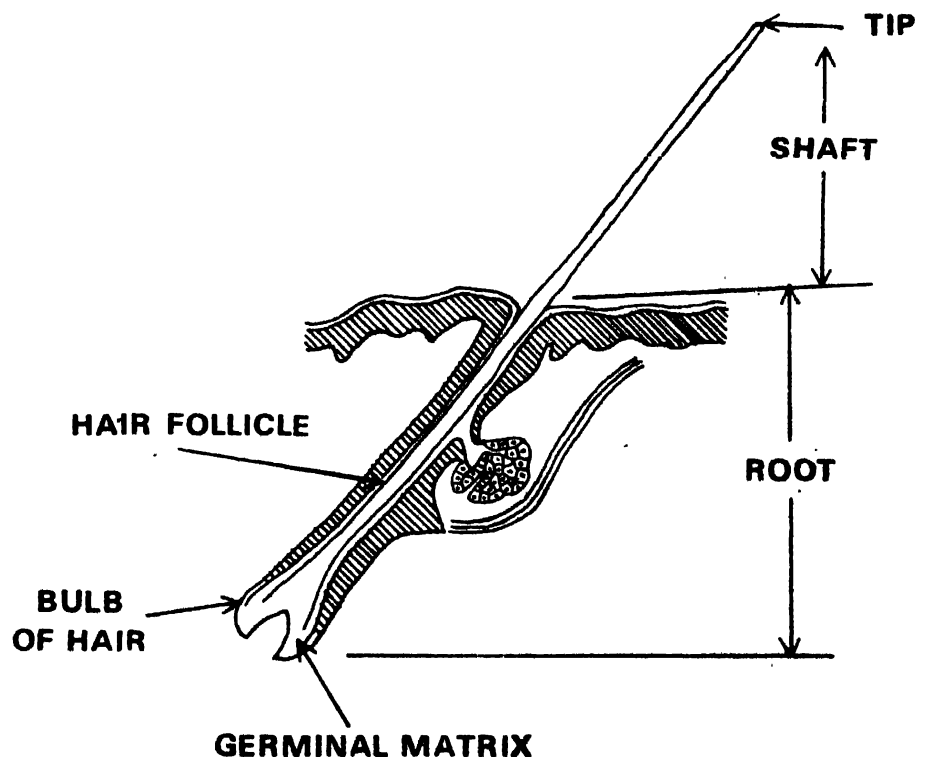


Fig. 1

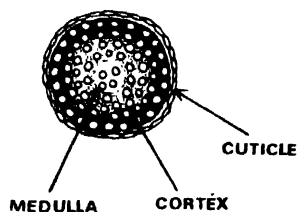
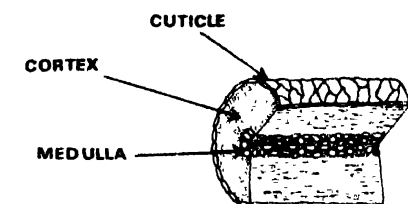


Fig. 2

the medullary index (M.I.) is important. M.I. is the ratio of the diameter of the medulla to the diameter of the whole hair. This ratio is calculated at the point where the hair is thickest. M.I. is measured with the help of microphotography or a microscope fitted with eyepiece micrometer. Table 1 shows how M.I. determines the nature of the animal whose hair is under examination. Table 2 shows how M.I. determines the part of human body to which the hair belongs.

There is a possibility of being misled by hair-like fibres such as feathers, insects' legs, wool, cotton, hemp, etc., collected from the scene of crime. A simple microscopic examination can easily discern and discard them. A first hand observation is sufficient to determine colour, curliness and length of the hair.

The careful examination of hair may also give the following vital information :

(a) Profession of the person whose hair is under examination. A mechanic's hair contains metal dust; miller's flour-dust; brick-layer's brick-dust and a garrage-worker's grease and petrol, etc.,

(b) The part of the body to which the hair belongs; and

(c) The nature of the deformity of the hair (for instance, burning,

cutting, shooting, scalding, etc., which is intimately connected with the nature of crime).

For the preparation of hair for microscopic examination they are mounted on glass slides; in most cases mounting in water or very dilute solution of glycerine is sufficient. If hairs collected from the scene of crime are very long, they are cut into pieces of suitable length. To prevent them from mixing up, the pieces are duly marked by coloured wax. After thorough examination of the adhering dirt the hairs are cleaned by alcohol or ether. Hair of dead bodies lying on ground for a sufficiently long period get reddish due to the chemical reaction of humus of the soil.

Study of the deformity of hair sometimes leads to important inferences as to the nature of the weapon involved in homicidal crime. The deformity determines how many times the victim has been struck. In cases of multiple blows longitudinal splits can be seen on the shaft of hair. Sharp and right-angled cutting surface without any split indicates the use of a sharp knife or scissors. Similarly, uneven stepped cutting surface with several splits along with a crushed shaft's end indicates the use of a blunt weapon such as an axe, hatchet, wooden stick, etc. Deformation of hair caused by burning, lightning, electric current, open flame, etc. is of various kinds. Hair, when scorched by heat becomes curled, slightly swelled and greyish. Sometimes air-bubbles, arrayed like beads in a necklace, are seen within the internal part of hair. A careful naked eye observation can detect the type of singeing (which can be confirmed under a microscope). Scalding by hot water or steam deforms hair just as when it is burnt upto 250°C. Typical necklace beads formation takes place within the hair. Below 250°C and above 175°C hair becomes reddish and the cells of medulla are scorched.

Table 1

Value of M.I.	Name of animal
1. less than 0.5	Human beings, certain monkeys
2. Nearly 0.5	Cow, horse, goat and some other animals
3. Greater than 0.5	All other animals not mentioned above.

Courtesy : "Le Poil de l'homme et des animaux" By Lambert Balthazard.

Table 2

Part of the body	Value of M.I.	
	For Man	For Woman
Neck	0.115	0.163
Forehead	0.132	0.148
Eyebrows	0.236	0.233
Eyelashes	0.095	0.146
Beard	0.260	X
Genitals	0.153	0.114
Ampits	0.102	0.179

Courtesy : "Le Poil de l'homme et des animaux" by Lambert Balthazard.

The most important as well as the most difficult task for the forensic scientist is to identify an individual from his hair. In most cases only a few pieces of hair are collected from the scene of crime and so it is difficult to study all of its vital aspects. First, the length of the hair (if it is in full original length) and the average diameter of the medulla are measured. M.I. is then calculated and colours are carefully compared. In determining M.I. the diameter of the medulla is measured at the thickest region of the hair. Careful examinations of the medulla, the root and the pigmentation of the cortex are also important. Cross-sections are measured and compared. To determine if hair is dyed, a micro-chemical examination is made to ascertain if it has been dyed with salts of bismuth or lead, nitrate of silver, permanganate of potassium, pyrogalllic acid, paraphenyldiamine, henna, etc. If all these signs are alike,

there is a probability of identity, but only a very close examination can strengthen this probability.

The results of hair examination can, however, never be accepted as the only confirmatory evidences;

they have to be supported by other evidences.

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the bottom for a considerable period (10min-12min) for grazing. Further, sea cows resemble elephants in having the testis placed inside the abdomen.

There are only two living species of sea cows existing today—the manatees and dugongs.

Manatees (*Trichechus*) live in coastal waters of the West Indies, north eastern coast of South America and extend upto Amazon, Central America and north of Florida. The body measures about 4 meters to 5 meters long and weighs about a ton.

## The mermaids

**M**ANY of us have read about mermaids in fairy tales and classical legends. They have been described as being half beautiful maidens and half glistening fishes. The possession of mammary glands and superficially fish-like tail might easily have given rise to such legends. Mermaids belong to an order of marine animals known as 'sirenia' popularly known as 'sea cows', well adapted to live in estuaries, bays and lagoons. The sea cows are believed to be distant descendents of some elephant-like creature of prehistoric age. These huge aquatic mammals are rather sluggish with streamline body, short neck and thick skin without hairs. The forelimbs are modified as flexible paddles and the hind limbs are absent. The nasal openings are small and the nostrils are valvular placed on the upper surface of the head and are closed under water. The eyes are very small and protected by muscular lids. The animal does not see well. The facial vibrissae are well developed. The upper lip is greatly developed to form a strong, yet sensitive pad reminding us somewhat of the pincer tips of the modern elephant's trunk. Teeth are broad and are used to seize sea weeds. They sometimes make their way to tropical river estuaries and eat fresh water plants such as water lilies. They are active by night. Sea cows differ considerably in structure from whales. Their bones are heavy enabling them to remain at

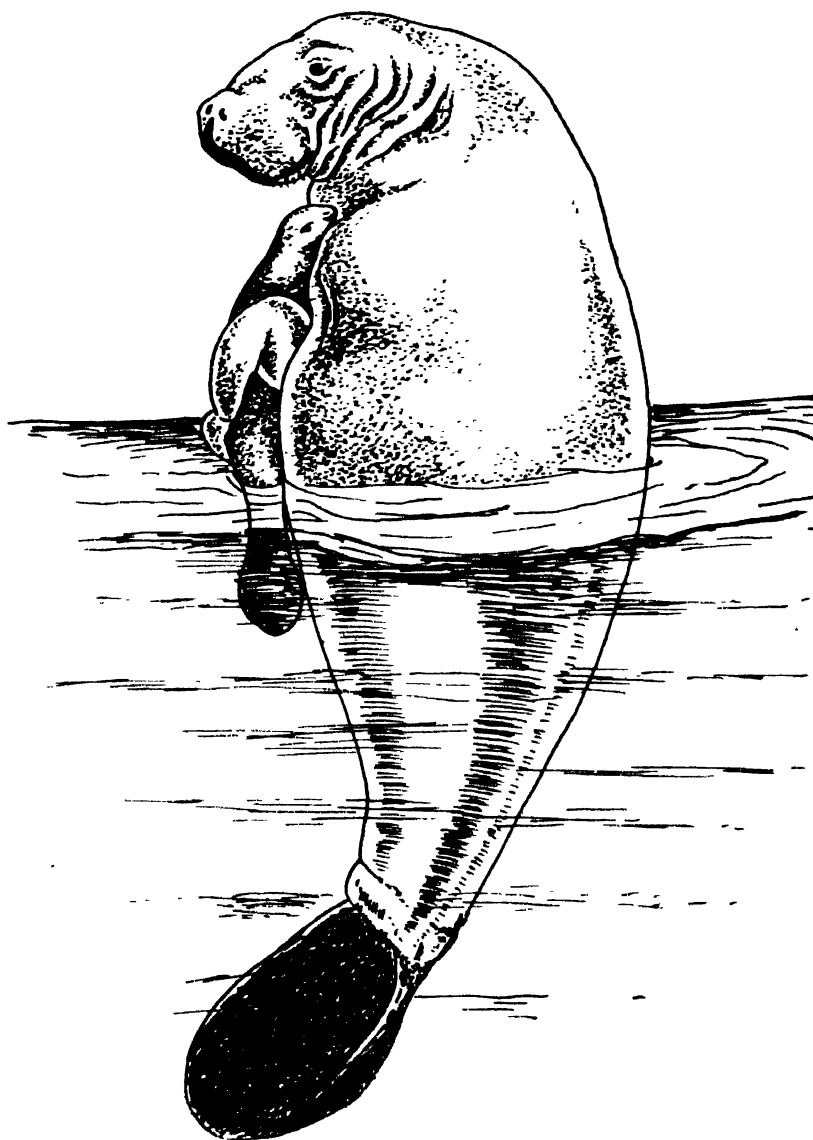


Fig. 1

The manatees spend a lot of time lying on the floor of the spring dozing, with their noses buried in the sand and their forelimbs bent half way under their chests for support. They are surrounded by a large number of fishes, mostly around the anus awaiting fresh faeces.

Dugongs (Halicore) are purely marine animals extending from the Red Sea throughout the Indian Ocean off Formosa, Australia, Africa and Malaysia. The dugong is larger and slightly longer than the manatee from which it also differs in having a forked tail, two tusks in the upper jaw of a male and a more rounded head. The maxillae are large. In other respects, however, it is similar to manatee.

Generally manatees and dugongs breed in winter and each cow yields only one calf at a time. The period of development of young one in the uterus (gestation) is one year. The young one born in a sheltered lagoon is able to swim soon after birth. The adult, when feeding her young one, raises herself half out of water and

holds the baby clasped closely to her body in a remarkably human manner (Fig. 1).

Formerly there was another species of this family known as Steller's sea cow (*Hydromalis*) which was first discovered in 1741. It often reached a length of about 9 meters. But for its size it was similar in appearance and feeding habits to the manatee and dugong. The teeth are replaced by horny plates. Whaling parties butchered the defenseless Steller's sea cow for meat and it became extinct in 1768.

One of the chief dangers threatening the mermaid is the fact that it is delicious to eat, and so extensively hunted. This has brought the animal close to extinction. Nowadays, however, it is protected and the population seems to be on the road to recovery.

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## Lord Rutherford

**R**UTHERFORD, one of the greatest experimental physicists of all time, had many important scientific achievements to his credit. He had shown that Becquerel rays from radioactive substances consisted of positively and negatively charged rays and the neutral rays discovered by the French physicist, P. Villard in 1900, were electromagnetic in nature; he called them  $\alpha$ -,  $\beta$ - and  $\gamma$ -rays and these are known as such till today. He also showed that  $\alpha$ -rays consisted of helium nuclei. With Frederick Soddy, he enunciated the Rutherford-Soddy

law of decay of radioactive elements into lighter elements. This law is analogous to a piece of a chinaware falling down the stairs and getting broken into smaller pieces at each step. He was awarded the 1908 Chemistry Nobel prize "for his investigations into the disintegration of the elements and the chemistry of radioactive substances."

With the assistance of his pupils, Geiger and Marsden, Rutherford made his greatest discovery—of the atomic nucleus—as a small concentrated positively charged central core of the atom in 1911. He also

devised an instrument called the scintillation counter for counting the number of particles coming out of radioactive substances. A million such particles constitute a rutherford in his honour. Then he was the first ever to achieve the transmutation of an element: conversion of nitrogen into an oxygen isotope by bombarding the former with  $\alpha$ -particles. He had predicted the existence of the neutron in the atomic nucleus which was later discovered by one of his pupils, Chadwick, in 1930, and which ushered in the age of atomic energy that dawned upon the world at large in the form of atomic bombs on Hiroshima and Nagasaki in August 1945.

Rutherford perhaps deserved two more Nobel prizes—the second one for the discovery of the atomic nucleus in 1911 and the third one for his transmutation of a chemical element into another in 1917—but it was then not the practice to award a second Nobel prize. However, he was honoured in other ways. He was knighted in 1914, made first Baron Rutherford of Nelson (his native place in New Zealand) and Cambridge and took his seat in the House of Lords in 1931. He was awarded the Copley Medal of the Royal Society in 1922. In recognition of his merit, he was appointed Director of the world-famous Cavendish Laboratory of Cambridge University to succeed his teacher, J.J. Thomson. He was elected president of the British Association for the Advancement of Science and awarded Order of Merit in 1925.

In short, during this century, Rutherford was to experimental physics what Einstein was to theoretical physics.

Rutherford was born on August 30, 1871 and died on October 19, 1937. Born poor, Rutherford died a poor man, leaving in his will only £ 7,000 the exact amount of the Nobel prize money.



Lord Rutherford

### Wit and humour

Lord Rutherford was a man of great wit and humour which his loud, enormous voice made more effective. The following examples are illustrative of his wit and humour.

*At the crest of the wave*  
At the 1923 meeting of the British Association for the Advancement of Science in Liverpool, Lord Rutherford announced at the top of his enormous voice, "We are living in the heroic age of physics." He was, of course, right and the next few years, 1924-32, saw the development of almost the whole of the quantum theory, the discovery of the neutron by James Chadwick which ushered in the atomic age; Cockcroft, working under him was claiming, "We have split the atom." Blackett had evidence to show the existence of the positron predicted by Dirac, all at the Cavendish Laboratories of Cambridge University where Rutherford was the Director. Around that time, some one remarked to Rutherford, "You are always at the crest of the wave." Rutherford confidently replied: "Well after all, I made the wave, didn't I?"

*Rutherford and relativity.*  
Einstein had put forward his Special Theory of Relativity in a paper in the German-language *Annalen der Physik* in 1905 but Rutherford did not accept it; he was highly sceptical about it. For a number of years, the impression that spread was that few physicists understood it. So much so that the 1911 physics Nobel Laureate German physicist Wilhelm Wien complained to the 1908 Nobel Laureate Ernest Rutherford, not quite aware of latter's reservations about Einstein's theory; "But no Anglo-Saxon can understand relativity." Characteristically, Rutherford replied, "No. they have too much sense."

*The Archbishop and Rutherford.*  
In a speech, Rutherford was candid enough to tell the audience: "As I was standing in the drawing room at Trinity, a clergyman came in, and I said to him: 'I'm Lord Rutherford.' And he said to me. 'I'm the Archbishop of York.' And I don't suppose either of us believed the other."

*Archbishop Lang and Rutherford.*  
Though an experimental physicist, Rutherford had read more novels than most literary people manage to do. However, during a meeting, Archbishop Lang had thought a famous scientist like Rutherford had no time for reading. After producing his list of the last month's reading, Rutherford asked "And what did you manage to read, Your Grace?" to which the reply was "... "A man in my position really doesn't have the leisure." Rutherford, having felt offended earlier, retorted, "Oh yes, your Grace. It must be a dog's life. It must be dog's life."

*"Dog's Moonshine".* Anglo-Saxon sceptic that Rutherford was, he did not believe atomic energy could be a reality in the foreseeable future and said so, as Heisenberg later recalled. However, in the true Rutherfordian style, he put it colourfully: He dubbed

technical utilisation of atomic energy as "dog's moonshine". This was, however much before Hahn's discovery of atomic fission in 1938.

*The tight shirt.* Finding a shirt tight, Rutherford explained to the Cambridge tailor "That shirt's too tight round the neck. Every day I grow in girth. And in mentality." Listening outside the cabin to the loud proclamation were the now well-known writer Sir C.P. Snow and a friend, then students at Cambridge.

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## Brain teasers

### 1. The null score

In a test comprising 26 questions, five points were deducted for each wrong answer and eight points were credited for each correct answer. If all the questions were answered, how many were correct if the total score was zero?

### 2. The intersecting circles

A circle of radius 15 cm. intersects another circle of radius 20 cm.

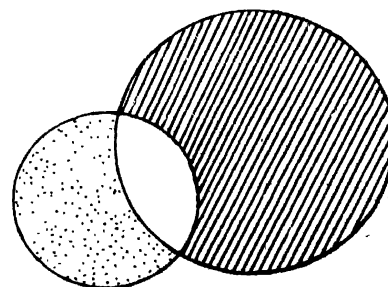


Fig. 1

(Fig. 1). What is the difference between the areas of the hatched and the dotted portions?

### 3. A match puzzle

Twenty matches are arranged in Fig. 2 in such a way as to form a geometrical figure comprising a hexagon and ten triangles. By merely removing two matches can you reduce the number of triangles to six?

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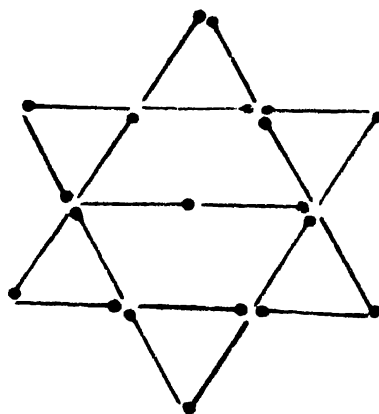


Fig. 2

## Science quiz

1. Stellarator is the name of a
  - (a) High energy particle accelerator
  - (b) Nuclear fusion reactor
  - (c) Fission reactor in the U.S.A.
  - (d) Matter and antimatter annihilator
2. Of the following physicists, who was a physician too?
  - (a) Albert Einstein
  - (b) Lord Rutherford
  - (c) Heike Kamerlingh Onnes
  - (d) Herman Helmholtz
3. Of the following scientists, who remained bachelor?
  - (a) Charles Glover Barkla
  - (b) C.V. Raman
  - (c) Isaac Newton
  - (d) Albert Einstein
4. Calculus was invented by
  - (a) Euclid
  - (b) D' Alembert
  - (c) Isaac Newton
  - (d) Galileo Galilei
5. Of the following, who was the son of a famous musician?

- (a) Tycho Brahe
- (b) Joseph Henry
- (c) Galileo Galilei
- (d) Wilhelm Konrad Von Roentgen

6. Of the following creatures, which are sensitive to gamma radiations?
  - (a) Honey bees
  - (b) Ants
  - (c) Men
  - (d) Dogs
7. Zerkina is the name of a
  - (a) Girl crowned as Miss Universe a few years back
  - (b) Nuclear reactor in India.
  - (c) Spacecraft to be launched by France
  - (d) Laboratory in Switzerland
8. First Variable Energy Cyclotron (VLC) is installed by Atomic Energy Department at
  - (a) Tata Institute of Fundamental Research, Bombay
  - (b) Indian Institute of Science, Bangalore
  - (c) Saha Institute of Nuclear Physics, Calcutta
  - (d) Bhabha Atomic Research Centre, Bombay

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(See page 211 for solutions)

## GENETIC ENGINEERING (Continued from page 246)

sequencing of DNA has been facilitated very much already.

On the other hand, there is a possibility that new recombinant organisms might spread world-wide incurable epidemics. If DNA with some repressed function happens to be transferred, it may result in unanticipated hazards.

### Further reading

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## FOR HER

### The truth about low-calorie sweeteners

**I**F you are overweight or diabetic, sugar in your diet must be substituted with low-calorie sweeteners. But you may wonder, which of these is safe? Cyclamate, once a popular sweetener in foods as well as drugs, was banned in 1969. Saccharin, the most widely used sweetener today, is also under suspicion. Continuing research and reviews of the tests conducted for determining the toxicities of these sweeteners seem to have convinced many experts that evidence against cyclamate is more doubtful than that against saccharin, the major ingredient of all marketed low-calorie sweeteners.

Canada banned saccharin in 1977. Canadian experiments on rats where the animals were fed saccharin as 5 per cent of their feed, confirmed earlier findings which had suggested a link between saccharin and bladder

cancer. About 10 per cent of the rats in the Canadian experiments had shown signs of bladder cancer. Experts estimated on this basis that about 4 people in every 10,000 who drink one bottle a day of low-calorie soft drink might develop bladder cancer due to the saccharin present. Further experiments seem to suggest that this conclusion may be wrong. In fact there is evidence to show that if users confine themselves to small doses of saccharin, they can escape bladder cancer caused by the sweeteners. In the experiments with rats the high saccharin content of the feed may have created very high concentrations of the substance in the bladder of animals, which caused the cancer. The amount of saccharin that one is likely to consume in a day will definitely not cause this kind of concentration.

With cancer producing substances (called carcinogens), there is usually a proportional relationship between dose and risk. This means that a carcinogen which can produce cancer in very large doses, can cause cancer in small doses too; but the extent of damage caused would be smaller in proportion to the quantity used. Fortunately the case of saccharin is quite different from that of other carcinogens, virtually every other known carcinogen is metabolised (i.e. broken and absorbed) by the body but saccharin is not. This is what makes the interpretation of the Canadian experimental results different from that of similar experiments using other chemicals.

Lactose, sorbitol, glucose or even cane sugar itself is often blended with saccharin to disguise the latter's bitter flavour and after-taste. This,

no doubt, increases the calorie intake to the extent these additives are present, but for the users, the blends are certainly more acceptable. (In many cases, complete abstinence from sugar is not called for.) Users of saccharin-based sweeteners must, however, limit their intake of saccharin, to be on the safe side. On no account should the consumption exceed the limit (set by the WHO) of 2.5 mg per day for each kilogram you weigh, i.e., about 12 tablets a day if you weigh 60 kg.

New sweeteners which have appeared in the news from time to time are aspartame and NEO-DHC. Aspartame (a dipeptide sweetener; L-aspartyl-L-phenylalanine methyl ester) has been found to be unsuitable for high temperature cooking. Besides, it becomes less sweet on keeping. NEO-DHC (neohesperidin dihydrochalcone) is a substance made from grapefruit peel. Its menthol or liquorice after-taste is a disadvantage. Tests so far on this sweetener have not revealed any toxicity. Liquorice extract too seems to be safe but its strong flavour limits its use to some type of sweets and medicines.

Well then, if you find that an artificial sweetener helps to keep your weight down, use it by all means but only sparingly till its safety is established. The risk of using saccharin is almost certainly less than the risk you run of premature death if you are overweight on account of the excess sugar you consume.

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# Science

## in

# Industry

## Use of citric acid in industry

**C**ITRIC acid  $C_6H_8O_7$  is chemically known as  $\beta$ -hydroxy tri-carballic acid. It is the most common acid of biological origin to become an article of commerce in the modern world. In almost all plant materials, citric acid or its salt is found to be present in varying proportions, sometimes only a few milligrams per kilogram, in others such as lemon up to 50 gm per kilogram. It is also present in animal tissues and body fluids. Milk is found to contain upto 1.2 gm per litre; bone and teeth about 3 gm per kilogram; semen about 5 gm per litre; blood serum about 0.025 gm per litre; and human urine between 0.2-1.2 gm per litre.

Citric acid was first obtained in pure form from lemon juice by Karl Wilhelm Scheelm in 1784. But only in 1860 the acid was first produced in commercial quantity in England from calcium citrate brought from Italy. Later in 1923 Curie developed another method for commercial production of the acid called surface fungal fermentation and this was again improved by employing a

new technique called submerged or deep fermentation process. Now almost all citric acid is prepared by fermentation using molasses as starting material. Citric acid is produced in either hydrated form containing one molecule of water as water of crystallisation or anhydrous form. The acid is highly soluble in water.

### Industrial significance of citric acid

As an important industrial chemical citric acid has many applications. In beverages, food and pharmaceutical industries the acid is used in huge quantity. Besides, it has also other important industrial uses such as in metal cleaning, plating and electropickling, etc. In developing countries like India, citric acid is used almost exclusively as a preservative for beverages and food processing. The pharmaceutical use also is rapidly growing.

### Beverages and food

The most useful qualities of citric acid such as high water solubility, extremely low toxicity and pleasant sour taste make it an ideal acidulant for aerated water beverages and food industries. As an acidulant it is widely used in soft drinks, syrups, jellies, jams, processed foods, candies and frozen fruits, etc. Besides this important act the acid also helps as an ideal preservative, flavour enhancer, antioxidant, pH regulator in many food and pharmaceutical industries. It also prevents harmful effects like deterioration of colour and flavour by sequestering trace metals present, particularly in processed foods.

In soft drinks, citric acid tablets are mainly used, which consists of citric acid, an alkali metal bicarbonate, a sweetening agent and various flavours. When tablets dissolve in water they effervesce carbon dioxide

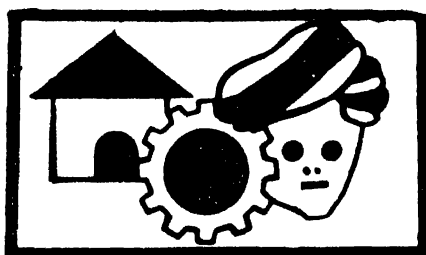
due to the reaction of citric acid with the alkali bicarbonate. Besides providing instant soft drink the acid also gives the desired degree of tartness and natural fruit flavour. Sufficient citric acid is added to the drink to maintain a final pH of 2.5-4.5. In wines and ciders the presence of turbidity due to iron-phosphate and iron-tannin complexes create problem for the industry. This is successfully avoided by addition of citric acid, which dissolves the complexes. For fruit and vegetable juices the acid provides a lower pH, which exerts a protective effect on juice pigments. Its presence in grape and other fruit juices enhance the flavour of the juice. In the preparation of jellies and jams citric acid is added as an acidulant to maintain the pH range where pectins can act as satisfactory jelling agents. It also provides the required tartness, tang and flavour to jellies. The acid is an important additive for candies to prevent graining or crystallisation of sugar mass. In ice-cream and processed cheese, the acid is used as an emulsifier.

### Pharmaceutical and cosmetics use

The acidulant property of the acid to enhance flavour of syrups, solutions and elixirs makes it a leading chemical in pharmaceutical industry. Usually, the acid is used in the form of sodium citrate. The salt is prescribed in the form of tablets or powders as blood and urinary alkalizer. It also acts as a good anticoagulating agent for blood. This property of the acid is used in blood banks for collection of blood. The blood is usually drawn from the donor under aseptic condition into sterile bottles containing 50 ml. of 4% solution of sodium citrate in isotonic sodium chloride solution. Sodium citrate is also used as a buffering agent in many pharmaceutical preparations.

*(Continued on page 235)*





## TECHNOLOGY FOR VILLAGES

### Herbicide for control of parthenium and other weeds

**M**ANY obnoxious weeds such as *Parthenium hysterophorus* pose a serious threat to agriculture, animal husbandry and dairy industry. Manual uprooting of parthenium is not only costly but it also causes dermatitis to allergic persons. The use of persistent herbicides is also not desirable because of their residual effects and consequential hazards to ecology, whereas short-lived herbicides tend to be ineffective. In both cases, the amount of herbicides applied is much in excess of the amount required for the control of the weeds because of the need to compensate the loss of herbicide by drifting, leaching, evaporation and decomposition. At present, formulations based on 2, 4-D, such as Weedone-48, Weedar-96 and Fernoxone, are being used. Precise data

on the demand for the product are not available.

In order to overcome the limitations mentioned above, the National Chemical Laboratory (NCL), Pune, has developed a novel, controlled-release, selective, pre-emergent and cheap herbicide formulation for the control of parthenium and other weeds. In this formulation a minimum dose of herbicide is released in a controlled manner at a fairly constant rate for a desired period of time with minimal threat to ecology. The NCL process involves the preparation of 2,4-dichlorophenoxyacetylchloride from 2,4-D and its treatment with a waste cellulosic material such as saw dust under suitable conditions. The technical material is suitably granulated. The new product has the following advantages over the 2,4-D formulations available in the market : (1) Quantity of active ingredient per acre is much less than in the conventional formulations; (2) No repeat application is needed; (3) There are no drift hazards to adjoining crop; (4) It is more effective since translocation due to rains, etc., is minimum; (5) Since it is granulated, its application is easier; (6) It costs less; and (7) Many undesirable effects of 2,4-D are eliminated (germinating grasses grow; soil residues are minimum). The product prepared in the laboratory has been tested by a number of agricultural research institutes and industries, and has been found effective in controlling parthenium and other weeds in grazing, irrigated and agricultural fields where crops such as sugarcane, maize, wheat, jowar

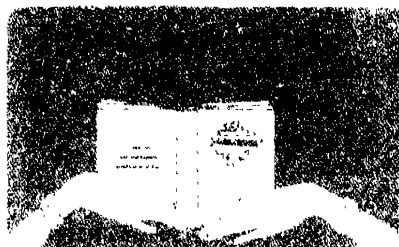
and rice are cultivated.

The herbicide, with a particle size distribution of 150-200 US mesh, has a pH of  $2.9 \pm 0.1$  and bulk density of  $0.8 \pm 0.1$  g/cc. Its main constituents are : cellulosic material,  $11 \pm 1\%$ ; soapstone,  $80 \pm 1\%$ ; urea,  $1.8 \pm 1\%$ ; and 2,4-D,  $7.0 \pm 0.3\%$ .

2, 4-D, lime, sawdust, soapstone, urea, nitrogen, thionyl chloride and dimethylformamide are the major raw materials required for the manufacture of the herbicide formulation. All these raw materials (technical grade) except dimethylformamide, which will have to be imported for the time being, are indigenously available.

The various items of plant and equipment required for the production of the herbicide formulation are: reactor (MS and GL), ribbon blender (MS), dosing tanks, storage tanks, hoppers, agitating vessels, heat exchangers, blowers, hot water circulator, vacuum pump, pulverizers, pneumatic conveyors and fluidized dryer. All these are either indigenously available or can be fabricated locally.

The laboratory has suggested a plant with a capacity of 300 tonnes/ annum of the technical product (2040 tonnes/ annum of formulated product) as the optimum economic-size unit. The capital outlay for a plant of this size has been estimated at Rs. 47 lakh (Rs. 5 lakh on and building, Rs. 15 lakh on plant and equipment, and Rs. 27 lakh as working capital). The ex-factory cost of production for the formulated product works out at Rs. 4.30/kg.



## BOOK REVIEWS

**TECHNOLOGICAL FORECASTING** by P. K. Rohatgi, K. Rohatgi and B. Bowonder, *Tata McGraw-Hill Publishing Company Limited*, 12/4 Asaf Ali Road, New Delhi-110002, 1979, Pp. 332, Rs. 87.00

**T**O plan for achievements of societal aspirations and goals, a pragmatic methodology is a necessary base. Manipulating the available resources by visualizing the future environment in advance has been the essential element of planning process. A falsome tool which embodies the three broad schools of thought—political, social and technical in the planning process, for a developing country like India is a dire necessity. Technology forecasting is a recent tool which has the capability of blending the technical and social imperatives. It is one of the reasons why India has made a spade work in this direction.

The book under review is the first comprehensive publication of its kind on policy-oriented subjects like technology forecasting and technology assessment with special reference to Indian situation. Technology forecasting is a tool for corporate planning. Determination of the probability of occurrence of an event, say, an invention or a discovery or development of a process, product or material on a given timescale which would be commercially exploited for the well being of society will enable the policy formulating and implementing agency to accord priority in resource allocation among

different alternative projects available on hand. In this regard technology forecasting helps the decision-maker.

First chapter gives an introduction to the subject and describes different types of technology forecasting. The exploratory type of technology forecasting recognises the relationship between past, present and future actions based upon which deliberate planning and execution of R & D projects are undertaken. Normative type of forecasting, which is mission-oriented, involves determination of future technologies to satisfy the anticipated future needs. Extrapolatory type of forecasting is an extension of present trend into future perspective. A statement such as "Technology Forecasting permits society to achieve a more desirable future gradually instead of through giant steps or violent revolutions" (p. 16) is an idealistic one and not a feasible solution to the problems of Third World countries whose economic interests are remote controlled.

Methodologies of technology forecasting, statistical formulae used and historical growth in different countries are described in sections two to four. To give an idea of likely future events intuitive method of technology forecasting is used which involves mental exercise of experts in the respective fields. Individual forecasting, opinion polls, panel discussions, brainstorming exercises, scenario writing and Delphi techniques are briefly discussed under intuitive method of technology forecasting. The other major methodologies of technology forecasting covered in the book are substitution techniques, growth curves, and dynamic modeling. Theory is supplemented by mathematical models and graphs wherever necessary. Technology assessment and its relationship with technology forecasting is dealt within section five. It is the study of the impact of present

and future technologies on societal and ecological system.

The following techniques are used in technology assessment. The cost-benefit analysis compares the total costs to total benefits in terms of present values. Multiple network technique tries to assess the order of effects when a technology is introduced into a society. Cross impact analysis studies the interaction between events and impacts to change the future consequences of individual technologies. Operations Research technique is basically a quantitative methodology in which relationships between different interactions are quantified in a model. Questionnaire approach is the most commonly used method to assess the impact of technology on the basis of intuitive contributions and expert opinions.

The author's plan to integrate technology assessment and technology forecasting with economic planning of India to make future events more controllable and also desirable must be given due importance.

Applicability of technology forecasting techniques is discussed in chapter six. Using trend extrapolation technique forecast for production of high HP electric motor in India, volume of air travel in Indian Airlines, increase in consumption of fertilizer per hectare of cropped area by the year 1980-90 are graphically shown with high confidence level, which could form the basis of planning for the decade. A worthwhile study (p. 77) which establishes a relationship between employment generation and investment required has been cited in the book. It should also be realised that employment generation is not only a function of investment in rupees but also a function of socially useful and productive work, which is a reflection of the philosophy of the prevailing social system, whether it is service-motive or profit-motive.

Sectoral studies on food and agriculture, education, energy resour-

ces and health and family planning services in future India are lucidly discussed in sections seven to ten. Magnitude of the problems in each sector is quantified, and technologies required for solving the problems and the probable dates of availability are identified.

Future economic, political and social systems in India are highlighted in section eleven. Some of the attributes such as inequality reduction between the poor and rich in developing countries will remain only a day dream unless a radical change occurs in the existing social system.

The book is highly useful to students of science policy and men engaged in policy formulation and implementation programmes in government agencies, institutions, academic institutions and industries in private and public sector organizations.

V GOVINDARAJULU  
RAM NARAYAN

**SCIENCE OF ENGINEERING MATERIALS Vols. I & II** by Manas Chanda, *The Macmillan Company of India Limited*, 2/10, Daryaganj, New Delhi-110002, pp. 247 + XVI and 264 + XIX, Rs 15.25 and 15.50 (1979).

WITH the increasing need of developing sophisticated materials with desired properties, the study of material designing is becoming important. The varied problems of designing materials to suit a specific purpose and the range of applicability of the devised materials make the 'science of materials' interdisciplinary in nature. The subject is now equally relevant to an engineer, a physicist, a chemist or a medical scientist. In this context, these introductory volumes on the science of engineering materials will be welcomed by the academic community. These are the first two of the

volumes written by an expert in the field engaged in teaching and research in Indian Institute of Science, Bangalore.

The first volume, consisting of five chapters, deals with the structure of matter. In Chapter 1, discussing the basic concepts of atomic structure of matter, the author has elaborated the subject in a logical manner. The engineering materials used are generally in solid-state. So, in order to develop the subject, the author, in Chapter 2 and 3, has given a good account of the interatomic and intermolecular forces and formation of different states of matter including the amorphous state. Formal accounts of the atomic arrangements of crystalline solids and different types of crystal imperfections are included in Chapter 4 and 5.

The second volume has six chapters which deal with materials. Chapter 1 presents a brief, general study of the systems in which two or more phases occur together in equilibrium, while Chapter 2 describes in detail the different phases and phase transformations in an important engineering material-iron-carbon system. The last four chapters of this volume describe the four main groups of engineering materials—metals and alloys, polymeric materials, ceramics and composites. Here the author has discussed nicely the behaviours of different materials relating to their internal structure and environment.

Both these volumes are written with care and with the intention of presenting easily readable material to the students who have undergone basic courses in physics and chemistry. The book is amply illustrated and the diagrams have generally been clearly printed; some of them, however, need improvement.

The bibliographical notes given at the end of each chapter, while reminding the readers of the introductory nature of the book, give valuable directions for more detailed reference.

which should have been listed, are not given. The students will benefit from the problems given at the end of each chapter. The get-up of both the volumes including printing, binding, etc., is of a good standard.

The book is highly recommended for the students of materials science.

BIBEK BANERJEE

**MODERN PHYSICS AND QUANTUM MECHANICS** by E.L. Anderson, *The Macmillan Co. of India Ltd.*, 2/10, Ansari Road, Daryaganj, New Delhi-110002 (1979), Pp 430, Rs 24.75

THE book under review is a cheaper Indian reprint of the American edition of the original text. Although the word "Modern" is incorporated in the title, the book has nothing much to do with modern physics. Nor does it intend, as the author himself clarifies in the preface, to give an adequate coverage to various topics related to modern physics. The book primarily aims at introducing to the readers the basic concepts, principles, and techniques of quantum mechanics. In pursuit of this goal, the author first attempts to develop certain concepts and ideas from modern physics which he considers essential for the understanding of quantum mechanics in the later part of his book.

The book is divided into eleven chapters. The introductory chapter gives an account of the Special Theory of Relativity with some illustrations of its role in contemporary physics. Chapter 2 describes how attempts to explain the energy distribution in the black-body spectrum led to the revolutionary idea of the quantization of electromagnetic radiation, namely, that radiation consists of discrete packets or bundles of energy, called quanta or photons. This chapter also brings out the dual, i.e.,

which is explained by regarding the photon as a wave packet.

Chapter 3 describes the Bohr model of the atom and some other concepts of interest. Chapter 4 first gives a brief description of the "old" quantum theory which is illustrated by the Sommerfeld treatment of the hydrogen atom and then goes on with the development of the wave mechanical formalism involving de Broglie particle-wave concept and the Schrodinger's wave equation. Applications of the Schrodinger's formalism to one-dimensional problems form the basis of Chapter 5, which also incorporates the quantum theory of the linear harmonic oscillator. A summary of the postulates of quantum mechanics and the essentials

of matrix mechanics appears in Chapter 6. Angular momentum operators and their eigen functions are treated in Chapter 7 while Chapter 8 is devoted to a discussion regarding implications of the spin-orbit interaction.

In the application of quantum mechanics to real physical systems some approximate techniques need to be developed, for there are few physical problems that are amenable to exact solution. The various approximate techniques, including the widely used perturbation theory, are described in Chapter 9. These techniques are applied in the subsequent chapter to some specific atomic problems. Finally, in Chapter 11 a discussion appears on some scattering

problems which are treated quantum mechanically.

More than 250 problems have been included in the book. Each chapter is followed by a list of references. A brief summary is also given at the end of almost every chapter. Some appendices also appear at the end of some of the chapters. The exposition of the text material is logical as well as simple and systematic. The book is an excellent text on quantum mechanics and may serve as a ready reference for physicists. It may prove useful for the students of quantum physics at the post-graduate level.

P.K. MUKHERJEE

### Books received

1. **INTRODUCTORY CHEMISTRY** by M. Katyal, *Oxford University Press*, 2/11, Ansari Road, Daryaganj, New Delhi-110002, pp. 288, Rs. 10.50
2. **ALTERNATIVE SCIENCES** by Ashis Nandy, *Allied Publishers Pvt. Ltd.*, 13/14, Asaf Ali Road, New Delhi-110002, pp. 151, Rs. 40.00
3. **HOMOFABER: Technology and Culture In India, China And** The West by Claude Alphonso Alvares, *Allied Publishers Pvt. Ltd.* (address as above), pp. 276, Rs. 60.00
4. **PROBLEMS IN PHYSICS** by Dhar, Chopra, Sehgal and Sehgal, *Sultan Chand & Sons*, 4792/23, Daryaganj, New Delhi-110002, pp. 8.86, Rs. 25.00
5. **QUANTUM MECHANICS** by Kakani & Chandalia, *Sultan Chand & Sons* (address as above), pp. 645, Rs. 27.50
6. **NUMERICAL PROBLEMS IN CHEMISTRY** by Sarin and Sarin, *Sultan Chand & Sons* (address as above), pp. 545, Rs. 12.50
7. **MODERN PHYSICS** by Sehgal, Chopra and Sehgal, *Sultan Chand & Sons* (address as above), pp. 431, Rs. 15.00

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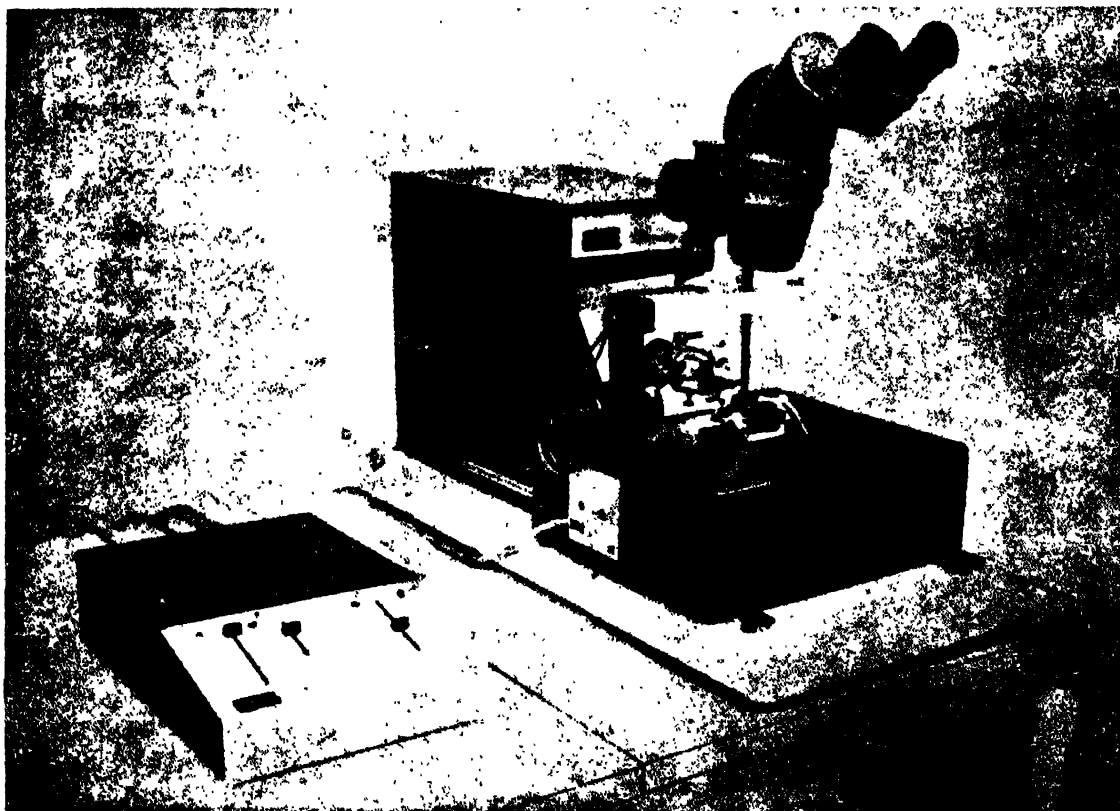
of reading such a nice and informative magazine like *S.R.* Since science has deeply penetrated into our life, the need is to make it more to comprehend even to

layman. It should not be confined to a particular class only. Therefore I suggest you to devote a page for 'Glossary of scientific terms' explaining the various terms, symbolic names

in layman's language. I hope this would attract a large number of readers from other disciplines.

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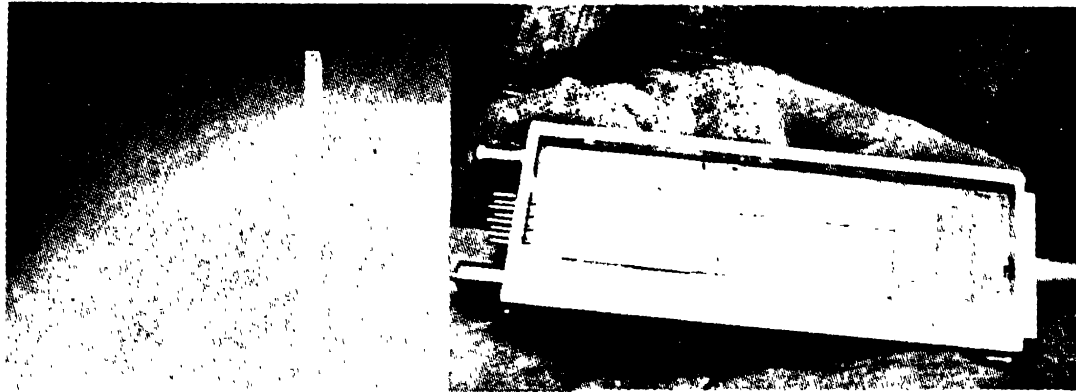
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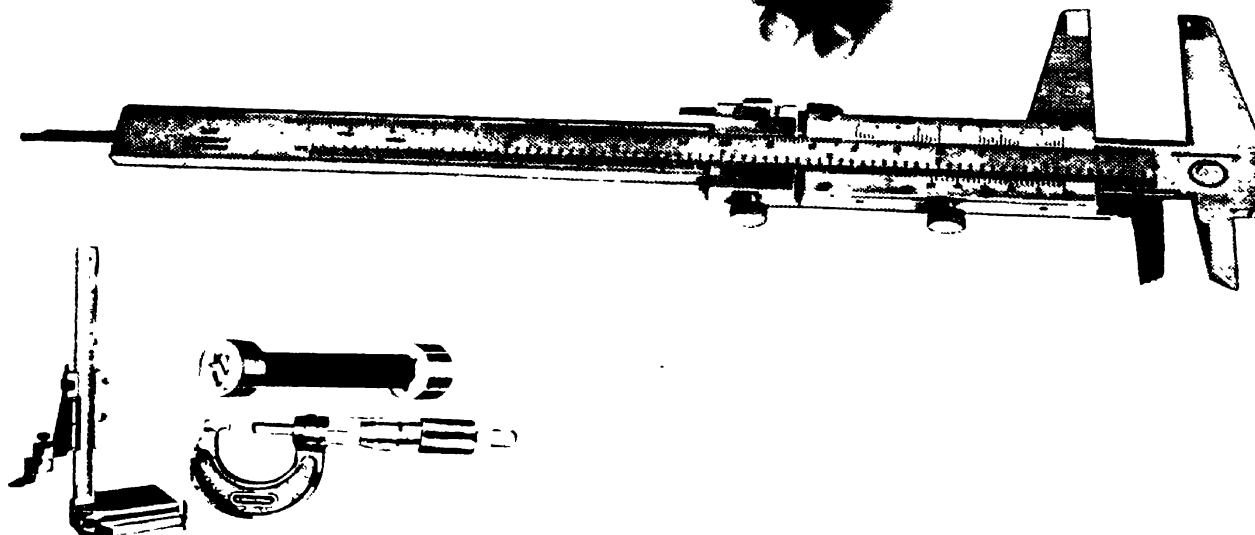
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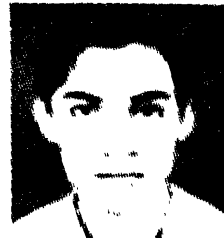
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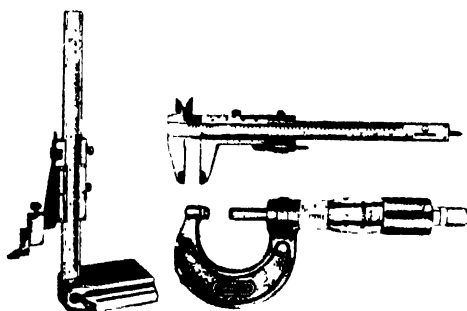
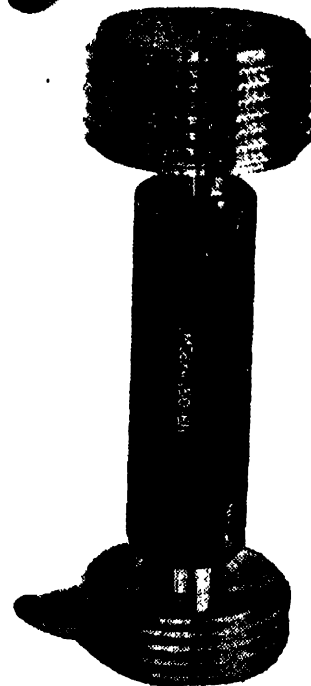
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## Indian names of constellations

Sir, It has been a great pleasure for me to go through the serialised articles on "Star watching" and the feature "Planets and their positions" published every month in S.R.

In the issue of November 1979, page 786, in the piece on *Nakshatras* it is stated that "Unlike the Babylonians or the Chinese the ancient Indian astronomers were not particularly interested in the study of stars or the preparation of star catalogues. Their interest in stars and constellations largely centered around those which lie along or near the ecliptic. (That is why we do not have Indian names for most of the non-equatorial constellations.)"

Here I would like to mention that our ancient learned men did not leave any field or subject incomplete in any aspect. The only thing is that we may not have studied about all their contributions most of which are in Sanskrit and can be found only in some little-known books. After years of effort, I have been able to compile a list of the ancient Indian names for most of the non-equatorial constellations which I am sending herewith.

My search for Indian names of the constellations began with my first identification of the star groups as given in star charts contained in *Allied School Atlas* published by Allied Publishers, New Delhi. I learnt the European names and their English meanings from the book, *The Observer's Book of Astronomy* published from London in 1965.

## Indian names

### (A) Northern Constellations

1. ASHVA-MUKHA (*Ashva*=horse)  
(*Mukhamu*=face)
2. UCHAIŚ SHRAVA (horse of Indra which has wings)
3. UTTARA MUKUT (*Uttara*=northern)  
(*Mukutam*=crown)
4. KARABHA (baby camel)
5. KALIA (=the serpent)
6. GARUDA (=eagle)
7. JAMBUKA (=fox)
8. THRI-BHUJA (triangle)
9. DEVAYANI (wife of Yayati)
10. BRUHAD-RUKSHA (*Bruhat*=great)  
(*Ruksha*=bear)
11. BHUJAGA-DHARI (*Bhujaga*=serpent)  
(*Dhari*=bearer)
12. BHU-TAPAH (meaning not known)
13. YAYATI (a king-rescued *Devayani* from a well and fell in love with her and married her)
14. RAJA-HAMSA (swan)
15. LAGHU-RUKSHA (*Laghu*=little)  
(*Ruksha*=bear)
16. VISHVA-KADRU (Hunting dog)
17. VRUSHA-PARVA (king of *Daityas* & father of *Sharmistha*)
18. SHARA (arrow)
19. SHARMISTHA (Princess, daughter of king *Vrushaparva* who was proud of her position)
20. SHARGNAPANI (*Shrgna*=bow) A bow  
(*Pani*=holder) hunter
21. SHAURI (Krishna=a hero in Indian mythology. He subdued *Kaliya* a serpent with many venomous heads)

## Corresponding European names

- EQUULEUS (=little horse)  
PEGASUS (=winged horse)  
CORONA BOREALIS (=Northern Crown)  
CAMELOPARDUS (Giraffe), added in 1690 by Havelius.  
DRACO (=dragon)  
AQUILLA (=eagle)  
VULPECULA (fox), added in 1690 by Havelius.  
TRIANGULUM (Triangle)  
ANDROMEDA (wife of Perseus)  
URSA MAJOR (Great Bear)  
OPHIUCHUS (Serpent bearer)  
Not known  
PERSEUS (rescued Andromeda chained to a rock and fell in love with her and married her)  
CYGNUS (Swan)  
URSA MINOR (Little bear)  
CANES VENATICI (hunting dogs), added in 1690 by Havelius.  
CEPHEUS (husband of Cassiopeia)  
SAGITTA (Arrow)  
CASSIOPEIA (lady in the chair who was proud of her beauty)  
BOOTES (The huntsman)  
HERCULES (A hero in Greek mythology. He killed Hydra, a serpent with many venomous heads)

Later I purchased many books on *Jyotishyam* in Telugu and tried to take out the Indian names for various *Nakshatras*. Casually, when I was looking into a Telugu dictionary by name *Andhra Vachaspathyam* compiled by Sri Kotra Shyamala Kama Sastri and published by The Orient Publishing Company, Madras-Tenali-Hyderabad in 1959, I found the names of various star groups under the word *Rikka* (a Telugu word for star). There it is mentioned as follows :

(A) The stars which are north of *Rasi Chakra* in the sky have been divided into 25 *Rasulu* (=constellations), namely :

- (1) Ashva-mukhamu, (2) Uchais shra vamu, (3) Uttara-mukutamu, (4) Karabhamu, (5) Kaliyamu, (6) Garududu (7) Jambukamu, (8) Thri-bhujamu, (9) Devayani, (10) Bruhad-rukshamu, (11) Bhujaga-dhari, (12) Bhu-tapamu, (13) Yayati, (14) Raja-Hamsa, (15) Laghu-rukshamu, (16) Visva-kadruvu, (17) Vrusha-parvudu, (18) Sharamu,

Table 1. (Contd.)

Indian names	Corresponding European names
22. SARPA (serpent)	SERPENS (Serpent)
23. SARADHI (charioteer)	AURIGA (Charioteer)
24. SWARA-MANDALA (region of sound) may be	LYRA (Harp)
25. HRUDAYA (Heart)	(not known)
<b>(B) Southern Constellations</b>	
26. THIMINGILA (giant fish)	CENUS (Sea monster)
27. MRUGA-SHEERSHA (deer head) or MRUGA (deer)	ORION (Hunter), as per 'Amarkosh' Sanskrit Dictionary.
28. YAMUNA (the river)	ERIDANUS (The river Eridanus)
29. BRUHAT-LUBDHAKA (Bruhat = great) (Lubdhaka = hunter)	CANIS MAJOR (Great dog = hunting dog)
30. LAGHU-LUBDHAKA (Laghu = little) (Lubdhaka = hunter)	CANIS MINOR (Little dog = hunting dog)
31. NAUKA (ship probably of king Sathya- varatha)	ARGO-NAVIS (ship of Argo)
32. VASUKI (King of snakes)	HYDRA (Water snake)
33. CHASHAKA (cup)	CRATER (Cup)
34. DHWANKSHA (crow)	CORVUS (Crow)
35. NARASHVA (Nara = man) (Ashva = horse)	CENTAURUS (half man half horse)
36. VRUKA (Wolf)	LUPUS (Wolf)
37. PEETTHA (Aasanam = seat)	ARA (Alter = Daiva Peetham)
38. SHASHA (Hare)	LEPUS (Hare)
39. DAKSHINA MUKUT (Dakshina = southern (Mukut = crown)	CORONA AUSTRALIS (Southern crown)
40. DAKSHINA MATHSYA (Dakshina = southern) (Mathsyas = fish)	PISCIS AUSTR (Southern fish)
41. SHRUNGASHWA (Shruna = horn) (Ashva = horse)	MONOCEROS (Unicorn = horned horse), added in 1690 by Havelius.
42. PARAVATHA (dove)	COLUMBA (Dove), added in 1679 by Royer
43. SWASTHIKA (a bird)	PHOENIX (A mythological bird, added in 1603 by Bayer.

(19) Sharmistha, (20) Shargna-pani, (21) Shauri, (22) Sarpamu, (23) Saradhi, (24) Swara-mandalamu, and (25) Hrudayamu.

(B) The stars south of the Rasi Chakra have been divided into 18 Rasis (Constellations), namely;

(1) Thimingilamu, (2) Mruga-sheershamu, (3) Yamuna, (4) Bruhat-lubdhakamu, (5) Laghu-lubdhakamu, (6) Nauka, (7) Vasuki, (8) Chashakamu, (9) Dhwanakshamu, (10) Naraashvamu, (11) Vrukamu, (12) Peethamu, (13) Shashamu, (14) Dakshina-muku-

tamu, (15) Dakshina-matsyamu, (16) Shrungashvamu, (17) Paravatham, and (18) Swasthikamu.

If we remove the suffixes, namely, *mu*, *du* and *vu* from the above Telugu words, we get the corresponding Sanskrit words. In the above mentioned dictionary the Telugu meanings for the above Sanskrit names were not mentioned and as such I could not understand to which European names they corresponded. Later I found the Telugu meanings from Telugu-Sanskrit dictionaries. When compared, the

Telugu meanings of the Sanskrit names agreed with the English meanings of the European names of many star groups. In case of some constellations, namely, Cassiopeia, Andromeda, Perseus, Cepheus, etc., the Greek mythological stories about them were found to be very similar to the stories behind Sharmistha, Devayani, Yayati and Vrusha-parva, etc., as mentioned in Mahabharatam or Sri Madh Bhagavatam.

There is a mention of *Shimshu-mara chakra* in Sri Devi (or Sri Madh) Bhagavatam. It corresponds to circumpolar stars which are in the constellation Ursa Minor. I have listed the Indian names (Table 1) according to their meanings as I have understood them.

[Note: 'Jyotisham' is one of 6 Angas (=parts) of the Vedas which are believed to date back 3,000 years before Christ.]

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#### Science for all

Sir, It is most gratifying that CSIR is bringing science to the 'needy' (there are many) so upto date and superbly edited and presented in S.R. Its popularity can be judged from the fact that it is now available even in petty book and magazine stalls. I was never in two minds to spend a rupee if a new issue of S.R. was available anywhere. I can take it home or office and be sure that those around would enjoy and benefit by it. S.R. is certainly the best reading material one can buy for its price.

Your regular features such as "Planets and their positions" and "Guide to starwatching" help even the uninitiated to gaze through the realm of the heavenly bodies on silent nights in comprehension of limitless space.

I specially liked the News and Notes on the Nobel Laureates in your December 1979 issue. The write-up on Professor Salam is done in reverence and understanding of a great scientist ethnically close to us. It is indeed refreshing that science and genius can break all barriers—the right function of S.R.

I wish also to mention a few points on the "Science for the Young" column on **Fighting in animals** by A.K. Sinha in S.R., December 1979 issue. It is well done with drawings to attract and stimulate the young reader. However, I felt that the omission of reference to Konrad Lorenz's work in this context was unusual. Lorenz's (not B. O. Lorenz whom Sinha cites) "King Solomon's Ring" and "Man meets Dog" have a lot to say about fighting in animals. Unlike what is stated by Sinha, certain animals, to quote Lorenz, the 'peaceful' doves, fight until death, but the ferocious timber wolf does not kill its vanquished partner—an instinctive behavioural control mechanism prevents the deadly canine tearing the exposed jugular vein of the lowly loser. Again Sinha suggests that man alone kills his vanquished enemies—in some cases the enemy is let off, provided the surrender signal is rightly given. I would agree with Lorenz who suspects that the bowing to the victor, taking the hat off and perhaps also the 'Namaste' gesture of salutation among us, are surrender signals blocking the aggression act of the 'killer'. These remarks do not diminish the fine points of the article by Sinha, but are mentioned only to complement.

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### Disappointment

Sir, Being a regular reader of S.R., my attention was attracted to the article

**Experiments—why design them?** (S.R., December 1979) because, as I remember this is the first article on the subject. I read and re-read the article with interest though at the end I felt a bit disappointed.

The subject is of utmost importance to scientists and technologists. The author seems to have had this in view when he wrote the article. He has tried to explain the pitfalls of inductive inference by referring to the claim of an individual. However, the jump from the introduction to the problem is so sudden that I was thrown off my guard. Yes, we need to define our research problems very clearly. But what should have been stressed is that every experiment is "conclusion orientated" as every consumer product is customer orientated. After emphasising this point in the initial stages, he should have gone back to the individual's claim. The example about the pack of cards is superb but the one about the poor man appears to have been thrust on the article. This leaves behind the impression of a "stray thoughts" like an affair rather than a neatly written article and hence the disappointment.

By and large the attempt is well intentioned and I suggest that the author be requested to bring out in simple language a series of articles on statistics for the benefit of scientists and technologists.

RAMNATH R. JUWARKAR  
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### Avogadro's number

Sir, In the article **Experiments—why design them?** (S.R., Dec. 1979) C.K. Pradhan says that, "... equal volumes of all gases under the same conditions of temperature and pressure should always contain the same number of molecules. Known as Avogadro's number it is denoted by N" (p. 810, col. 1, last para). This statement leads us to believe that at all volumes, temperatures and pres-

ures all gases will contain N molecules. The truth, however, is that all gases will contain N molecules only at certain values of volume, temperature and pressure, viz., at N.T.P. when their volume is 22.4 litres.

MADHUKAR G. AWATRAMANI  
New Delhi-110027

### Jatinga bird mystery

Sir, I found the article **The Jatinga bird mystery** (S.R., September 1979) and related discussions in response to that (letters, S. R., January 1980) quite stimulating. However, I feel, we should depend more upon reasoning rather than consider what is believed at *Pakshutirth*. This place of pilgrimage provides just another example how in our country people are cheated by ascribing superstitions to not very impossible happenings. The belief that the same two birds have been visiting the place since 7th century is no less bogus than those Jatinga villagers' earlier thought that God had sent the birds to satisfy their hunger! Is not it the scientists' concern to replace such blind beliefs with facts and knowledge?

I think the stimuli operating on the birds for their unique movement is a combination of what Viswanathan and Anathasubramanian have individually suggested in their letters (S. R., January 1980). The fact that it occurs only in a fixed and limited region of the village suggests the primary reason to be a sudden change in the magnetic field of the place. Other noted environmental factors possibly assist this change of magnetic field in disturbing the psychological condition of the birds and thus stimulating the uncommon behaviour. It can further be assumed that the above disturbance and the outcome of the birds' unusual behaviour that follows leave a deep psychological scar in them. This assumption enables us to visualise the possible reason why the peculiar behaviour persists even after the essen-

tial factors were retracted as observed in case of the two birds Sengupta and coworker got from their balcony on 24.9.1978.

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### Eclipse and the eye

Sir, Regarding the letter of Pranesh Nigam (S.R., Dec., 1979), I would like to quote from a lecture of the eminent astrophysicist Prof. J. C. Bhattacharya. According to him, during a total solar eclipse, it becomes dark to the extent that even stars are visible clearly. Under these conditions, the pupil of the eye is fully open. The period of the total eclipse is very small and if one is looking at the sun when a portion of the bright disc suddenly reappears the pupil is not able to respond so quickly. This can lead to permanent damage of the retina.

The rarity of reports of such incidents of damage to the eye makes people take this warning lightly, whereas, in my opinion, this rarity is due to the rarity of the total solar eclipse itself.

N. RAJAN  
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### Immobilized enzymes

Sir, The article **Immobilized enzymes to aid food industry** (S.R., Dec. 1979) gives an introduction to the field of immobilized enzymes. It would have been appropriate to the title if the author had mentioned the processes using immobilized enzymes which are already taken up by industry for commercial production, viz., production of L-amino acids, 6-aminopenicillanic acid and high fructose syrup. Secondly, conversion of starch to glucose using immobilized glucoamylase has been studied only on a pilot plant scale with

a capacity to produce 4-5 million kg of glucose per year. It should be noted that even though food industry utilizes a large amount of soluble enzymes in a wide variety of uses, immobilized enzymes may be expected to compete only in those processes where there is a clear cut economic and technical advantage. Finally it would have been very useful if the author had listed our current and potential applications of immobilized enzymes in food industry.

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### Radiomimetic substances

Sir, In **Radiation mutagens and their mechanism of action** by T.P. Singh (S.R., November 1978), the author has defined "radiomimetic" substances as chemical substances which stimulate the biological effects of ionizing radiations. It is incorrect. As we know radiation mutagens were first to be discovered and used for the induction of mutations. The use of chemical substances to induce mutations was known later. At the beginning of World War II, C. Auerbach and J. M. Robson of Institute of Animal Genetics, Edinburgh, Scotland, used mustard gas and sulphur compounds on mice and *Drosophila*. They found that mustard gas and other related compounds produced all those effects that were known to occur in mice and *Drosophila* following X-ray treatment. Because of this resemblance to X-rays, mustard gas and related compounds were called "radiomimetic". But today, we know that though radiation and chemical mutagens can produce similar changes at phenotypic level in the living organisms, yet their mode of action with the genetic material and various other cytological effects are different. Furthermore, some of the chemical mutagens are specific in action and much more effective in inducing mutations

in comparison with the radiation mutagens. Thus, we see that chemical mutagens differ qualitatively and quantitatively to live up to appellation "radiomimetic". Of late, the term seems to have disappeared from the literature, and for good reasons. Therefore, today the term "radiomimetic" substances for chemical mutagens has a limited value.

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### Suggestions

Sir, I have been a subscriber to S.R. since 1966. It is a very attractive, impressive and interesting magazine for science students. I suggest the following:

Detailed articles on various common diseases found in India such as malaria, filaria, kala azar, leishmaniasis, arthritis, gout, rheumatism, psoriasis, tuberculosis, leprosy, cholera, measles, glaucoma, cataract, cough and catarrh, etc. may be published regularly. It will help even a common man to understand the diseases. I very much appreciated the article on **Osteomyelitis** (S.R., October 1979). My daughter suffered from this disease two years back. This article would have been proved very helpful, if I would have read it at that time.

Some articles on female diseases should also be published in place of such topics as "Food storing in refrigerator", "Think before you wear a bra", "Cold cream", etc.

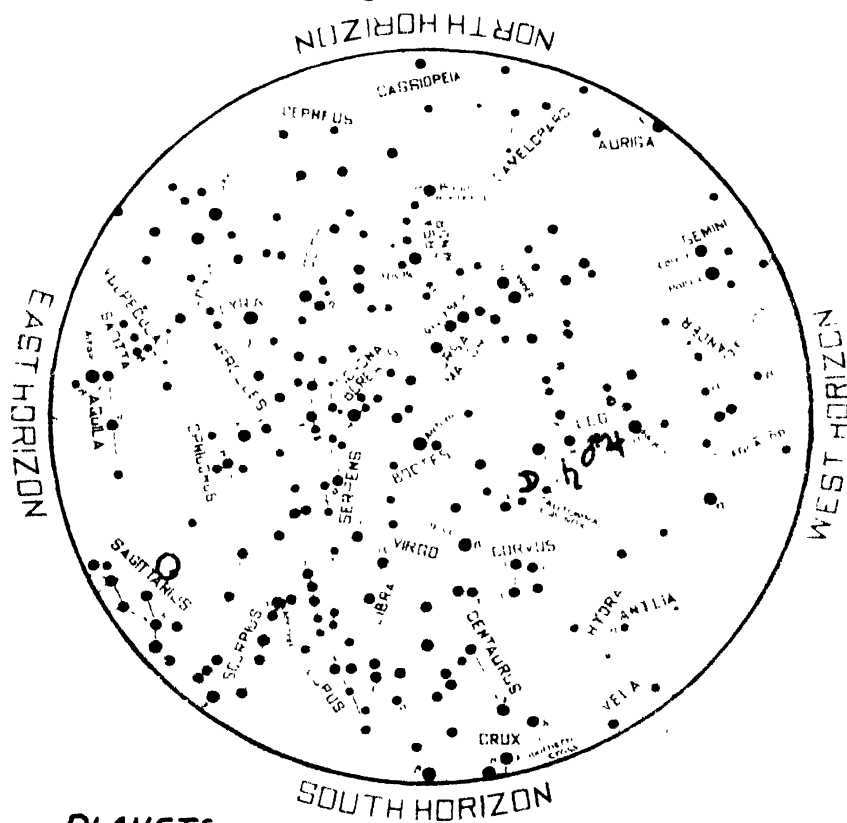
Your magazine has nothing for the children. Even in the "International year of the child" it has not paid attention towards children. Perhaps the children are the most neglected in our society. Can't you publish something regarding children under the heading "Child Care" or "Science for children."

M. A. ABBASI  
Khav College  
Basti (U.P.) 221001



# Planets and their positions

June 1980



PLANETS		MOON	
♂	MARS		
♃	JUPITER		
♄	SATURN		
		MAGNITUDES	
		1 2 3 4 5	
		0	FULL MOON 28TH

## The moon

NEW moon occurs on 13th at 2-08 a.m. and full moon occurs on 28th at 2.32 p.m. I.S.T. The moon passes about three and a half degrees south of Venus on 13th, four degrees south of Mercury on 15th, very close to Jupiter on 18th, about two degrees north of Mars in the evening of 19th and half a degree north of Saturn in the midnight of 19th. The lunar crescent becomes

first visible after the new moon day in the evening of 14th. The moon is at perigee or nearest to the earth on 9th and at apogee or farthest from it on the 21st.

The sun is at the summer solstice on 21st.

## The planets

Mercury (*Budha*), an evening star visible on the western horizon,

sets about one and a half hours after sunset during the first half of the month and about an hour after it during the second half. It is at the greatest eastern elongation of about  $25^\circ$  from the sun on 14th. It passes about half a degree north of Venus on 1st. It passes about  $8^\circ$  south of the star Pollux (*Punarvasu*) on 24th. It becomes retrograde on 28th. It moves from Gemini (*Mithuna*) to Cancer (*Karkata*). Its visual magnitude varies from  $-0.3$  to  $+1.9$ .

Venus (*Sukra*), visible in the evening sky, sets about one and a half hours after sunset during the first quarter of the month. Thereafter, it is too near the sun to be visible. It is in inferior conjunction with the sun on 15th. It reappears as a morning star on 20th and rises about an hour before the sunrise. It moves from Gemini (*Mithuna*) to Taurus (*Vrisha*) by retrograde motion. Its visual magnitude varies from  $-3.1$  to  $-3.8$ .

Mars (*Mangala*), visible in the evening sky, sets about half an hour before local midnight during the first half of the month and about an hour before it during the second half. It passes about  $2^\circ$  south of Saturn on 25th. It moves from Leo (*Simha*) to Virgo (*Kanya*). Its visual magnitude is about  $+1.1$ .

Jupiter (*Brihaspati*), visible in the evening sky, sets about an hour before midnight during the first half of the month and about two hours before it during the second half. It is in the Leo (*Simha*). Its visual magnitude is about  $-1.4$ .

Saturn (*Sani*) sets at about midnight during the first half of the month and about an hour before it during the second half. It is in quadrature with the sun on 11th. It is in Leo (*Simha*). Its visual magnitude is about  $+1.3$ .

(Source : Positional Astronomy Centre, India Meteorological Department, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700053)

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## "The lie-detector"

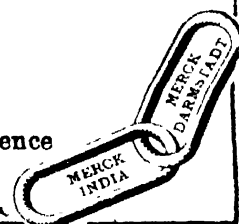


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**W** E get energy from many sources like the sun, radioactive materials, coal, water resources, oil and gas and forests. Among them oil is used most widely in some form or the other. All countries do not produce oil; some have vast resources of oil and they export it to other countries. The export and import of oil has today become an effective instrument for negotiations in the global politics. This shows how much we depend upon oil as a source of energy.

The continuing hike in oil prices and the realisation that its reserves are not unlimited has prompted many countries to increase their efforts to develop alternative resources of energy.

**S. RAJENDRAN**

**If trees are grown systematically and managed properly, they can provide bulk of energy required by men**

They have their own advantages and disadvantages. The possibilities of sabotage and accidents in nuclear power plants, with their high capital costs of installation and operation, nuclear power offers hardly a suitable option. Continuous use of coal and gas depletes their reserves and there is no continuous and guaranteed supply of coal to various thermal power stations. The cost of construction of dams across rivers for hydro-electric projects is prohibitively high. Under such conditions, we can tap solar energy either directly for heating, cooling, refrigeration

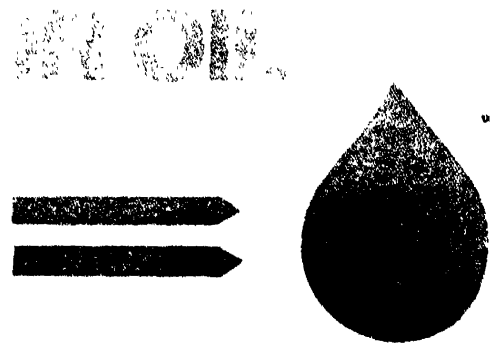
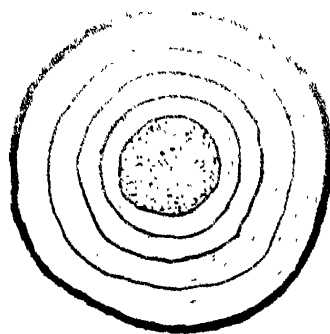
and crop drying or indirectly by growing trees which harness the limitless solar power and convert it into wood through the process of photosynthesis. If trees are grown systematically and managed properly, they can provide on a sustained basis the bulk of the energy requirements of any country. Let us see how wood can be substituted for oil.

#### **Wood conversion possibilities to obtain energy**

Like oil, wood also needs to be burnt to generate power in some form or the other like heat, steam or

mercially available (Robert, J.E., 1968).

Due to oil scarcity now, wood has started replacing it in the industries. Forest based industries such as wood pulp mills, saw mills and plywood plants can start installing furnaces which are designed to burn wood or wood waste or bark, to work a steam turbine or generator. When an industry has such a desirable combination of steam and electrical power demand, the relative efficiency of heat recovery from steam can be almost 75 per cent compared with 38 per cent at a modern facility generating electricity. In 1972, 37 per cent of the energy requirement of the pulp



electricity. The following methods illustrate how wood can be converted into various energy forms to meet the energy demand.

*Direct combustion.* This technique involves the burning of wood to produce steam or generate electricity and has been in use since long. For example, boilers using wood in place of oil or coal which generate as much as 320,000 kg per hour of steam at 1250 psi and about 510°C are com-

and paper industry of America, was met through the combustion of bark and spent pulping liquors (J.B. Grantham, and T.H. Ellis, 1974).

*Retarded combustion.* The wood is volatilized by retarded combustion to produce the producer gas which is a mixture of combustible and non-combustible gases. The calorific value of this gas when produced from wood or charcoal is about 3000 cal, per cubic m. In

Europe, there is a great development of producer gas equipment for cars, trucks and tractors and for stationary engines. In Great Britain, many stationary engines of varying power generating capacities as high as 500 h.p. are in operation using producer gas as the source of energy.

**Bio-conversion.** In this process wood is digested by anaerobic bacteria to produce methane which has calorific value of 18900 cal per cu m more than that of producer gas. This technique is applicable for disposal of unwanted forest residues, especially, cellulosic pulp mill and paper mill wastes. There is a recent interest in the potential use of cellulose as a source of fuel either by direct combustion, gasification or bacterial conversion to methane. Innovative methods of intensive short duration silviculture are producing exceptionally high yields of cellulose per acre and the technology of conversion is greatly improved (C.L., Brown, 1976).

**Chemical conversion.** Oil is used not only as fuel but also as a raw material in chemicals, synthetic fibers and many other related products. Wood can also be used for these purposes. New ideas have been developed to convert cellulose into chemical feed-stock for the plastic industry. It is well-known that cellulose is used for synthetic fibers. Recently, the U. S. Bureau of Mines designed a pilot plant for chemical reduction of wood chips, wood residue and barks to oil.

**Wood power for automobiles.** Producer gas and charcoal from wood can be used for automobiles. The former is now being largely used in motor cars and trucks as substitute for petrol or diesel in Germany. In using charcoal, there is less risk of fouling the engine and greater mileage. Briquetted charcoal gives approximately four times as much fuel substance as is contained

in the same volume of crude charcoal (J.H. Jenkins, 1936).

**Wood for electricity.** Oil is being replaced by wood in the industries as well as in the thermal power stations to generate steam for supporting the generator. A boiler that generates as much as 320,000 kg of steam per hour at 1850 psi and 510°C can support an electricity generating capacity of about 80 megawatts (J.E. Robert, 1968). On the assumptions of  $3.5 \times 10^6$  cal/ton of air dried wood, a thermal-electric conversion of about 60 per cent operating efficiency requires about 6,200 tons of wood annually. Therefore, if all wood (6.5 billion tons available for all wood purposes in the world) was used for electrical generation, maximum production from the world's forests would amount to  $1.0 \times 10^6$  Mwe (megawatt electric). The area of forests needed to provide wood for 1,000 megawatt electric plant would be between 900 sq km under the worst growing conditions and 161 sq km under the best. Provisions of wood fuelled electricity generating stations in forested regions can provide a ready outlet for trees dead or diseased as a result of fungus or insect epidemics.

**Wood power for domestic uses.** The increasing prices and scarcity of kerosene oil in the rural areas of most of the developing countries leave wood as the only alternative source for energy for domestic uses as wood is easily available to them. In the past five years, the long dormant wood stove industry has been brought to life by the oil crisis. People are finding that they can save money by putting a wood stove or furnace in their homes and then going out to the backyard for cutting down their own fuel. Several coal and oil burner manufacturers offer central heating systems that can operate on either wood or fossil fuel or both at the same time.

## Merits of wood

Wood, as a substitute for oil, has the following plus points.

1. Oil reserves are fast depleting and are non-renewable sources of energy whereas the forests which provide wood are renewable.

2. Oil has to be transported from the well to the places of its use, but the plantations can in most cases be grown adjacent to the areas where fuel-wood will be used, thus reducing the need for long distance transport.

3. Oil combustion creates the problem of sulphur removal, whereas wood combustion does not involve disposal problems.

4. Ash from wood combustion is usable as a manure and is rich in plant nutrients.

5. Oil spills during transit in seas kill the marine fauna and foul the entire region. As a result, fishing industry is greatly affected. Wood transport does not create such problems.

6. Drilling for oil exposes the soil to erosion but growing of trees not only safeguards the soil against erosion but also provides adequate quantities of clean water and pure air which is vital for man's survival on this planet.

## Conclusion

Many countries, not well endowed with fossil fuels, have little choice but turn to wood as a substitute for oil. Substituting wood for oil has not received the attention of investigators, obviously due to the free availability of oil till recently. At present, forests are being maintained or raised mainly for timber rather than for fuel-wood for which large-scale plantations of fast growing fuel-wood species are needed. The raising of trees requires much less capital investment than installing photovoltaic and photothermal gadgets to tap solar energy for use. (Photovoltaic cells convert light into

(Continued on page 305)

**I**F elementary particles are the fundamental building blocks of nature, the present day understanding of physical phenomena indicates that some "elementary particles" are not "elementary" at all. Others are not "particles", at least not in the usual sense of the word. The familiar proton, neutron, pi-meson and a host of other such particles, collectively called "hadrons", are certainly "particles", but they are not "elementary". They behave, as if they are composed of entities called quarks which are probably "elementary" though not really "particles" in the sense that they are

#### Four kinds of interactions

Physicists recognize four kinds of basic interactions in nature. These are in decreasing order of their strength :

(i) strong interaction, which is responsible for binding protons and neutrons together inside the nucleus of an atom;

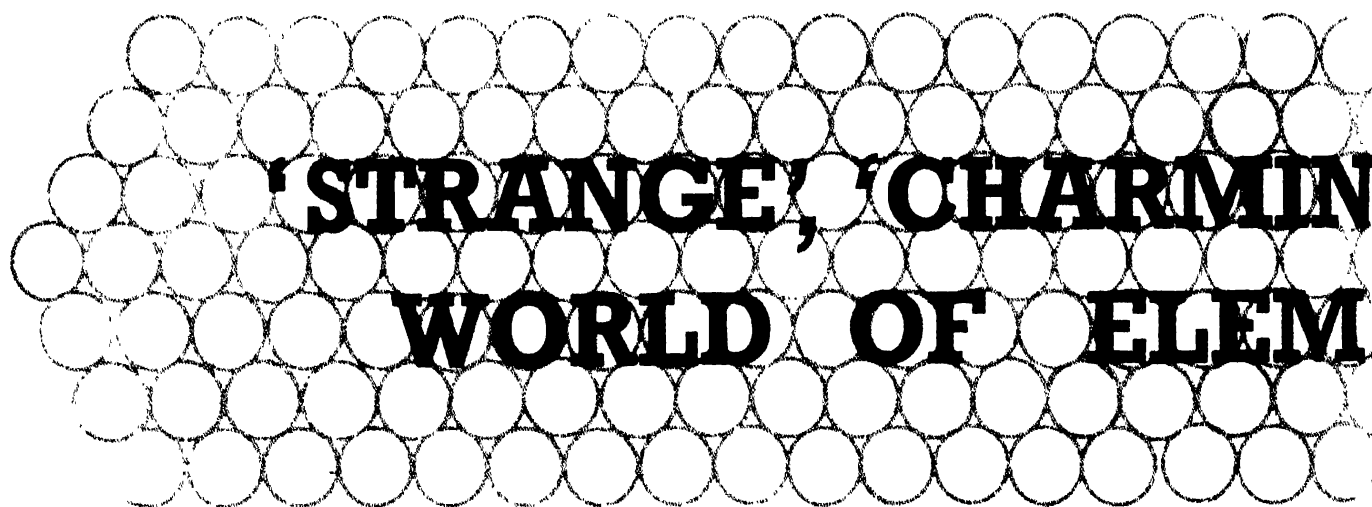
(ii) electromagnetic interaction, which holds an electron around the nucleus in an atom;

(iii) weak interaction, which manifests itself in the process of radioactive decay of some nuclei; and lastly,

it. Both leptons and hadrons, however, can take part in weak and electromagnetic interactions (only electrically charged particles take part in electromagnetic interaction).

There is, a lone particle called 'photon', a class by itself, which though itself does not carry electric charge, is the essential mediator of all electromagnetic interactions between charged particles. Another important

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MASROOR HASAN**



not observed as free isolated objects in nature. This kind of an illusory nature of the modern day physics of elementary particles is, indeed, a crisis that physicists are faced with. And it is these "hadrons" - the protagonists behind this crisis, which appropriately, will be the subject of our present discussion.

"Hadrons" are one of the two broad categories into which the whole spectrum of elementary particles is divided, the other category being "leptons", which, as far as we know, are both "elementary" and at the same time "particles".

(iv) gravitational interaction, which is responsible for keeping the planets in orbits around the sun.

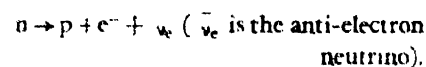
Gravitational interaction, being too weak in the realm of elementary particles, is insignificant and is generally not considered in studying physics of elementary particles. Among the other three interactions, strong interaction is important in the sense that it serves as the basic criterion for classifying the elementary particles into "hadrons" and "leptons". Leptons are conspicuous by their complete insensitivity towards strong interaction, while hadrons vigorously take part in

fact that places the hadrons in sharp contrast to the leptons is that hadrons far outnumber leptons which are strikingly limited in number. Starting with the familiar neutron, proton and pi-meson, there are now more than hundred hadrons known, including many highly unstable resonance particles with extremely short life times ( $10^{-23}$  sec), whereas, until 1975, leptons seemed to be content with only four known particles, viz., electron ( $e^-$ ), muon ( $\mu^-$ ), electron-neutrino ( $\nu_e$ ) and muon-neutrino ( $\nu_\mu$ ). It is this large population explosion in the hadron family that led physicists to

consider the hadrons as not elementary but as made up of further truly elementary constituents called quarks. Before embarking on the quark model of hadrons a discussion on a very important guiding principle in physics of elementary particles is essential.

physicists Enrico Fermi and S.N. Bose, respectively, who first studied the behaviour of these particles. Fermions, such as neutron (n), proton (p), Omega ( $\Omega$ ), etc., among the hadrons, are called 'baryons'. They all carry a 'baryon' quantum number of value +1 while the 'bosons' such as pion

present in its decay product. In fact, this observation has been raised to the status of a conservation law which states that baryon quantum number must be conserved in all interactions involving baryons. So, a neutron can decay into a proton as:



Baryon No. +1 +1 0 0

where the proton in the decay product conserves the baryon quantum number of the neutron. The conservation law does not allow a proton, the lightest

**Hadrons are certainly "particles" but they are not "elementary". They behave as if they are composed of entities, called quarks, which are probably "elementary" though not really "particles"**

## G' AND 'COLOURFUL' ELEMENTARY PARTICLES

### Principle of quantum number

All the important properties of a particle other than its mass can be uniquely specified with the help of a set of discrete numbers called 'Quantum Numbers'. Electric charge, spin, angular momentum and 'baryon number' are some of the typical quantum numbers for a particle. Electric charge, in general, can be positive (or negative) integer or zero. Each particle also has a definite spin quantum number either half of integers (i.e., 1/2 or 3/2 or 5/2, ... etc.) or integers (i.e., 0 or 1 or 2 ... etc.). The former types of particles are called 'fermions' and latter 'bosons', after the famous

( $\pi$ ), kaon (K), rho ( $\rho$ ), etc., are called 'mesons', all of which carry zero baryon number. Note that all leptons are also fermions while photon having spin quantum number 1 is a boson. It is to be pointed out here that corresponding to each particle there is an 'anti-particle' having the same mass and spin quantum number as that of the particle with all other quantum numbers reversed in sign.

The concept of quantum numbers is the direct consequence of the conservation laws of physics by which certain properties of the particles remain unchanged during an interaction. So it is noticed that a heavy baryon has another lighter baryon

among the baryons, to decay because there are no lighter baryons available to which it might decay. This kind of conservation laws which prohibit certain kinds of otherwise valid physical processes from occurring in nature also led to two other quantum numbers, called "strangeness" and "charm". It is found that K-mesons are never produced singly, whereas the joint production of a K-meson and its anti-particle, a phenomenon called 'associate production of strange particles', does occur in nature.

The production of K-mesons not in singles can be explained by introducing a new quantum number for the K-mesons. This quantum number,

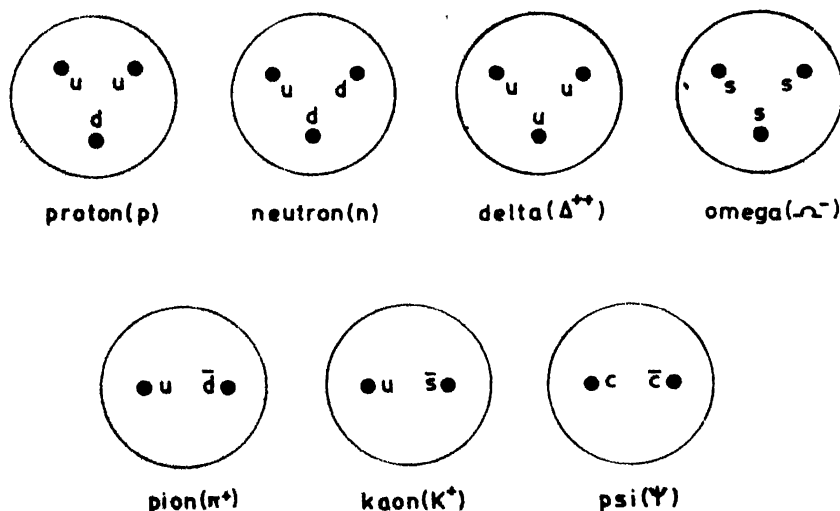
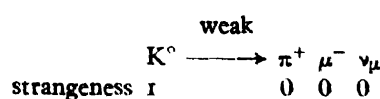


Fig. 1. Some of the well-known hadrons with their particular quark constituents

called "strangeness", is arbitrarily given the value  $+1$  for  $K^+$  and  $K^0$  and  $-1$  for their respective antiparticles,  $K^-$  and  $\bar{K}^0$ . The associate production, example, in the following type of strong interaction reaction



strangeness  $0 + 0 \rightarrow 1 + (-1) = 0$  can be explained by postulating a 'law of conservation of strangeness'. Here in order that total "strangeness" is zero, only a pair (or pairs) of kaons can be allowed to be produced with the members in a pair having opposite value of strangeness quantum number. Strangely, K-mesons have exceptionally long life time (about  $10^{-8}$  sec.) compared to other massive hadrons which decay to lighter particles via strong interaction (characteristic life time about  $10^{-23}$  sec.). Though produced via strong interaction, K-mesons have long life time because they decay only through weak interaction. In a sense the interaction is called "weak" because it takes longer time to act. However, as K-mesons are the lightest among all the strange particles, which include many strange baryons as well, the lightest K-meson can decay only to non-strange hadrons:



If we count the strangeness quantum number on both sides of this decay process, we see that "strangeness" is not conserved in weak interaction. This is an example of one of the conservation laws, which, though are strictly obeyed in strong and electromagnetic interactions, are violated in weak interaction. In fact, it has now become a general principle in physics; the weaker the interaction becomes, the more number of conservation laws it violates. To understand the introduction of yet another quantum number called "charm", knowledge of the quark model of hadrons is essential because the "charm" idea was originally introduced in the form what is now called a "charmed quark".

### Quark model

In its original version, the quark model which was proposed independently by two U.S. theoretical physicists, Murray Gell-Mann and George Zweig in 1963, deprived the existing hadrons of their status of being elementary by proposing that all

hadrons are composite states of three 'truly' fundamental spin  $1/2$  constituent called 'quarks'. They were labelled 'u' for 'up', 'd' for 'down' and 's' for 'strangeness'. The 'up' and 'down' refer to another quantum number called 'isotopic spin', which, inspite of its name, has nothing to do with the spin of a particle. It is, in fact, related to and manifested as the electric charge of a hadron.

What turned out to be most unusual thing about quarks was the electric charge assigned to them. The 'u' quark has charge  $+2/3$  and the 'd' and 's' quarks have charge  $-1/3$ . The baryon numbers of the quarks are also fractional,  $1/3$  for each quark. 'Strangeness', on the other hand, remains an integer (Table 1). The corresponding anti-quarks designated by  $\bar{u}$ ,  $\bar{d}$  and  $\bar{s}$  have their electric charges, baryon numbers and strangenesses reversed in sign. In this three-quark scheme mesons are built up from all possible combination of a quark and an anti-quark while baryons are constructed from combination of three quarks (antibaryons are constructed from combination of three anti-quarks). The quantum numbers of the hadrons are obtained from those of the constituent quarks by addition. For example, u and d quarks give the positively charged pi-meson ( $\pi^+$ ) in the following way:

	u	$\bar{d}$	$\pi^+$
Electric charge	$2/3$	$+1/3$	$=1$
Baryon number	$1/3$	$+(-1/3)$	$=0$
Strangeness	$0$	$+0$	$=0$

Similarly, the proton is made up of two 'u' quarks and one 'd' quark. The quark contents of a few well-known hadrons are given in Fig. 1 for conceptual visualization.

In the early part of the 1970s physicists began thinking of extending the original 'three-quark model' of Gell-Mann and Zweig to a 'four-quark' one by bringing in a new principle called 'lepton-hadron symmetry'. According to the principle four

**Table 1. Quantum numbers of quarks**

Quark flavours	Spin ( $J$ )	Electric charge ( $Q$ )	Baryon number ( $B$ )	Strange- ness ( $s$ )	Charm ( $c$ )
u (up)	1/2	+2/3	1/3	0	0
d (down)	1/2	-1/3	1/3	0	0
s (strange)	1/2	-1/3	1/3	-1	0
c (charmed)	1/2	+2/3	1/3	0	+1

(rather than three) fundamental quarks of the hadronic world would match well with the four known leptons in a theory which would unify these two major worlds of elementary particles. Subsequently, it was theoretically but subtly demonstrated that a fourth quark called 'charm' (c) would explain the non-existence of a certain kind of weak interaction involving hadrons.

The idea of the 'c' quark which is assigned an electric charge +2/3, baryon number +1/3 and 'charm' quantum number equal to +1 (anti-charm ( $\bar{c}$ ) quark having the quantum numbers reversed in sign) met with success in 1974 with the discovery of the  $\psi$  (psi) or J-particle (as it was called by two separate groups who independently discovered it), which was immediately recognized as a new meson made of a charm quark (c) and an anti-charm ( $\bar{c}$ ) quark making the net 'charm' of  $\psi$ /J equal to zero. However, the existence of a whole spectrum of new hadrons overtly carrying a non-zero 'charm' value (e.g., when c ( $\bar{c}$ ) combines with any of  $\bar{u}$ ,  $\bar{d}$ ,  $\bar{s}$  (u, d, s) as described earlier) is not at all ruled out. The eagerly awaited discovery of these particles will certainly give additional support to this already accepted quark picture of hadrons.

### Colour

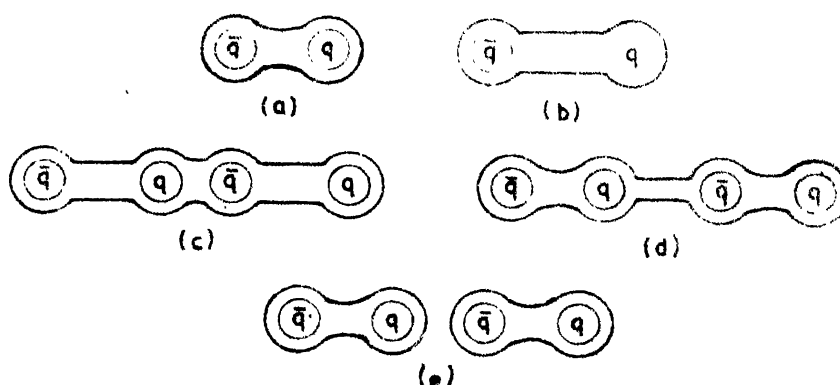
The quark model, though extremely successful in describing the existing hadrons, runs into a serious difficulty if probed deeper. Quarks, we recall, are fermions (spin 1/2) and so are expected to satisfy the well-known

Pauli's Exclusion Principle which, in the present case, states that no two quarks having all their quantum numbers same can make a hadron. However, in at least three baryons,  $\Delta^{++}$  (uuu),  $\Delta^-$  (ddd) and  $\Omega^-$  (sss), at least two constituent quarks have all their quantum-numbers same, which apparently violates Pauli's principle. The contradiction is removed by proposing a new quantum number for the quarks, called 'colour'. The four quarks—'u', 'd', 's' and 'c'—are called the four 'flavours' of quarks, each 'flavour' now in three possible 'colours'. So the number of quarks is three times the number of quark 'flavours'.

The 'colours' for a quark are conventionally taken as the three primary colours, viz., red (r), blue (b) and green (g). So the 'colours' of the three 'u' quarks in  $\Delta^{++}$ , for example, are postulated to be all different even though the other conventional quantum numbers for them are the

same. The Pauli's principle is therefore resurrected. But, now, we have an additional postulate which says that the colours of the constituent quarks must be so chosen that a physical meson or a baryon should have 'no net colour', i.e., they must be 'colour less'. It must be noted that in the above discussion 'colour' has nothing to do with the physical colour that we observe in nature; it only helps us visualize an abstract concept.

In spite of sporadic reports by groups of experimenters who claim the discovery of a free, isolated quark, no sufficient experimental evidence exists. Some theoretical physicists believe that quarks will never be observed. They have even been partly successful in developing a theory in which the interactions between the quarks are permanently confined within the hadrons. Any attempt at separating, for example, a quark and an antiquark inside a meson results in production of a new quark-antiquark pair (a meson). The process is similar to breaking a bar magnet, which produces a new dipole rather than separate the original north and south poles. This phenomenon for quarks is illustrated in Fig. 2, which comes within the framework of a recently developed theory called 'Quantum Chromodynamics' which has been developed along the



**Fig. 2.** The energy spent in trying to force apart (b) a quark-antiquark pair in a meson (a) goes into creating a new quark-antiquark pair (c) which ultimately leads to two separate mesons (d, e)



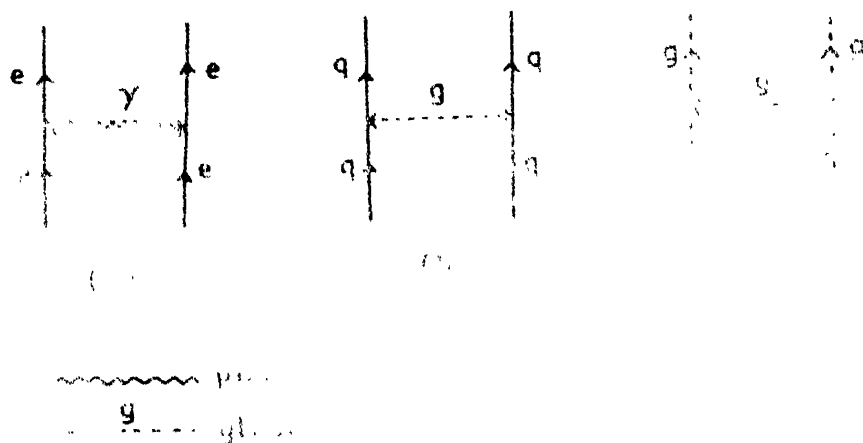


Fig. 3. Schematic diagram showing: (a) electromagnetic interaction between two electrons where a virtual photon is emitted and reabsorbed; (b) strong interaction between two coloured quarks mediated by the exchange of a virtual gluon which may itself be 'coloured' thereby giving (c), gluon-gluon strong interactions via the exchange of another gluon

line of the theory of quantum electrodynamics. The latter describes the electromagnetic interaction among the electrically charged particles.

In quantum electrodynamics, the force between two electrically charged particles is mediated by the exchange of a virtual photon which, by itself, is chargeless and massless. In the case of quantum chromodynamics, however, the force between the 'coloured' quarks is mediated by particles called 'gluons' which like photons are also massless, spin 1 particles. It may be observed that 'colour' in quantum chromodynamics takes the role of 'electric charge' in quantum electrodynamics. In quantum electrodynamics, the photon being electrically neutral is only a carrier and not a generator of electromagnetic field. But in quantum chromodynamics, in addition to the 'coloured' quarks, 'coloured' gluons, which are the carriers as well as the generators of 'colour field', are also present. So in quantum chromodynamics we have gluon-gluon interaction (Fig. 3) in addition to the usual quark-quark interactions. This novel feature of quantum chromodynamic leads to an interesting consequence.

The attractive force between two

quarks seems to decrease as the distance between the quarks decreases and finally vanishes asymptotically at zero separation. This is exactly opposite to what is observed in quantum electrodynamics where the electromagnetic force between two charged particles decreases (approximately as the inverse of the square of the separation) as the separation between the particles increases. So, according to quantum chromodynamics, at very short distances the quarks should essentially behave as free particles (i.e., as if not interacting with each other), a behaviour called 'asymptotic freedom'. This has also been observed in the high energy collision of electrons with protons. In such collisions electrons get scattered at large angles as if scattered by free point-like objects (quarks) inside the proton, in much the same way as Rutherford's famous alpha-ray scattering experiment revealed the existence of a central nucleus inside an atom.

The long distance behaviour, on the other hand, shows the opposite trend. The attractive force between the quarks grows stronger as the distance separating them increases and ultimately it becomes impossible to separate the two quarks. This is called

'Infrared slavery' which in a way leads to permanent confinement of quarks inside hadrons. At present, this is the most widely accepted theory that explains the non-existence of an isolated quark.

### 'Truth' and 'beauty'

All that has been said regarding the hadrons does not mean that it is all quiet on the leptonic front. In addition to the well-known four leptons, a new lepton called 'tau' ( $\tau$ ) was discovered in 1975. It is also thought to be associated with its own neutrino, increasing the total number of leptons up to six. This, in turn, leads those physicists, who believe in a quark-lepton symmetry, to extend the four-quark theory to a six-quark theory by hypothesizing two new quark flavours called "truth" or "top" (t) and "beauty" or "bottom" (b). Indeed, another new particle called "Upsilon" was reported in the 1978 International Conference on High Energy Physics held in Tokyo. The Upsilon is supposed to be a bound state of a bottom quark and an anti-bottom quark ( $b\bar{b}$ ) just as  $\psi/J$  particle is a bound state of a c and a  $\bar{c}$  quark.

### Conclusion

While experimenters are busy discovering new particles, a section of theoretical physicists has turned its attention towards realizing Albert Einstein's dream of unifying all interactions of nature in one single theory. Recently conjectured 'Grand unified theory' of strong, electromagnetic and weak interactions is a pointer to that direction. In this theory, all three interaction strengths become equal at extremely short distances (or, equivalently, at extremely high energy  $10^{16}$  GeV). At such a staggeringly high energy, leptons and quarks are viewed to behave essentially alike and the apparent distinctiveness in their behaviour is due to the fact that physicists have not yet been able to

explore such a high energy. A novel prediction of such a grand unified model is that baryon number is not really conserved; so the proton may actually decay (!) notwithstanding the earlier discussion on strict conservation of baryon number in baryon decay. The proton, which is known to have a half-life of the order of  $10^{30}$  years, is being subjected to extremely subtle experiments to discover such an

instability. The final unification of gravitational interaction, with the other three, which till now remains unachieved, will only lend an aesthetic completeness to this "strange", yet "charming" and "colourful" world of elementary particles.

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## WOOD AS SUBSTITUTE FOR OIL (Continued from page 299)

direct current like that produced by batteries and with the aid of a power conditioner, it is even possible to convert direct current (DC) into alternating current (AC).

Now, that the price of crude oil has gone up by a substantial amount, to avoid the oil squeeze or petropinch further it is right time to find a substitute for oil. Wood is with us in plenty and technology for its conversion into

energy is proven. So why should not we switch over to wood?

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### IMPORTANT

#### CHANGE OF ADDRESS

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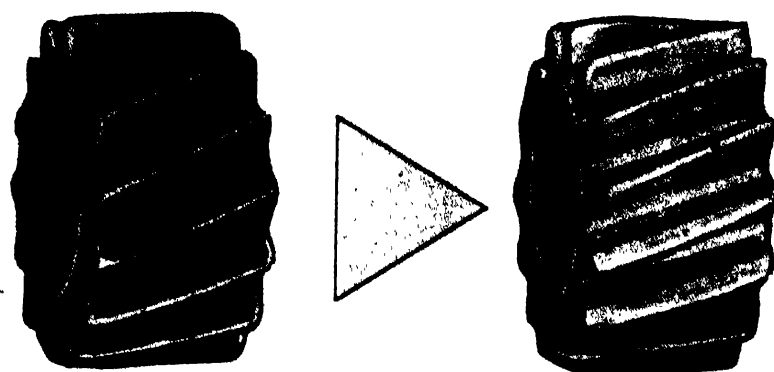
**M**ACHINING, the method for the removal of a material from a metal workpiece (to be machined into a particular shape) by the use of a tool piece, is an important process in industry. It gives more precision for a desired design, shape and finish of workpiece and more economically than that obtained manually. In recent years, with the rapid increase in the use of tough, hardened metals difficult-to-machine alloys for industrial development, much attention has been paid to devise new, more

the hardness of workpiece increases, the problem of finding suitable and sufficiently hardened material for tool piece becomes more difficult. Consequently, the machining of workpiece made of high strength alloy becomes cumbersome and inconvenient. Grinding techniques, which rely on moving abrasive tools, can sometimes be employed. But they are slow and the range of shapes that can be fashioned with them is limited.

The conventional machining

which are otherwise difficult or even impossible to be machined by conventional methods.

There are mainly two types of electro-machining techniques which employ electricity for the operation. These include the spark erosion or electrical discharge machining (EDM) based on spark discharge effect, and the electrochemical machining (ECM) which makes use of controlled corrosion or anodic dissolution process in electrolysis. The operation of EDM (see S.R.,



**B. K. SHARMA**

**ECM offers a unique method for cutting minute shapes in hard materials that cannot be shaped by conventional machining**

## **DYNAMIC ELECTRO-CHEMICAL MACHINING FOR HARDENED METALS**

efficient and economical metal removal processes

The conventional methods for machining, e.g., turning, shaping, planing, trepanning, milling, drilling, broaching, etc., have successfully been used in the past for simple jobs. These conventional chip techniques rely on the use of a machining tool which is much harder than the workpiece. But the tool is subjected to process-induced stress and wearing so that one has to change the tool quite often. As

methods are unsuitable for cutting minute shapes, especially in exceedingly hardened material. The work can be done by hand using hand tools (as in die making) but it requires more time besides great skill and labour for complicated contours and shape design. A new, promising and unconventional type of metal removal technique for such applications is the electrochemical machining (ECM). It is suitable for shaping extremely hard materials

March 1978) involves high frequency electric spark discharge between a soft metal tool and the workpiece (to be machined) through a dielectric liquid (mineral oil, low viscosity oil, kerosene oil, etc.). The rate of machining is maintained uniform by controlling electronically the gap distance between the electrodes. The cutting tool which has no electrical contact with the workpiece, can be made of a soft, easily worked material such as brass. Machining operations that can be easily accomplished by this method include drilling for making holes of almost any shape and of any cross-section using brass electrode, forming of cavities in

dies, tapping, grinding, etc. But EDM is not popular as it is slow. Also, shapes of only limited sizes can be machined by this technique.

### Electrochemical machining

The concept of electrochemical machining was set forth in a British patent as long ago as 1929. However, its use in practice is relatively new. The fundamental basis of the presently known ECM process—a combination of chemical and mechanical means was laid by T.M. Gussev (Russian) and C.F. Burgess (American) in the early 1940s. Since then the technique has gained rapid appreciation as a versatile process of stress-free machining of various kinds of metals, hard materials and super-alloys. It is especially useful when complicated contours which are costly and beyond the scope of conventional machining processes are to be generated or when several conventional machining operations are to be accomplished in a single stage operation.

### How ECM process works

The ECM process employs electricity to produce chemical changes occurring in an electrolytic cell (Fig.1). The electrolytic cell contains a suitable electrolyte (fused salts or aqueous solutions of acids, bases and salts) between the anode *A* (workpiece being machined) and the suitably shaped cathode *C* (shaping tool). These electrodes are connected to a source *B* of direct current in an external circuit. Usually the process is a low-voltage and high-current-density system. As current passes through the electrolyte between the electrodes, the metal is removed atom-by-atom from the anodic workpiece in a pattern established by the shape of the cathodic tool. Thus, a true replica of the tool can be made on the workpiece without any physical contact between the two. This

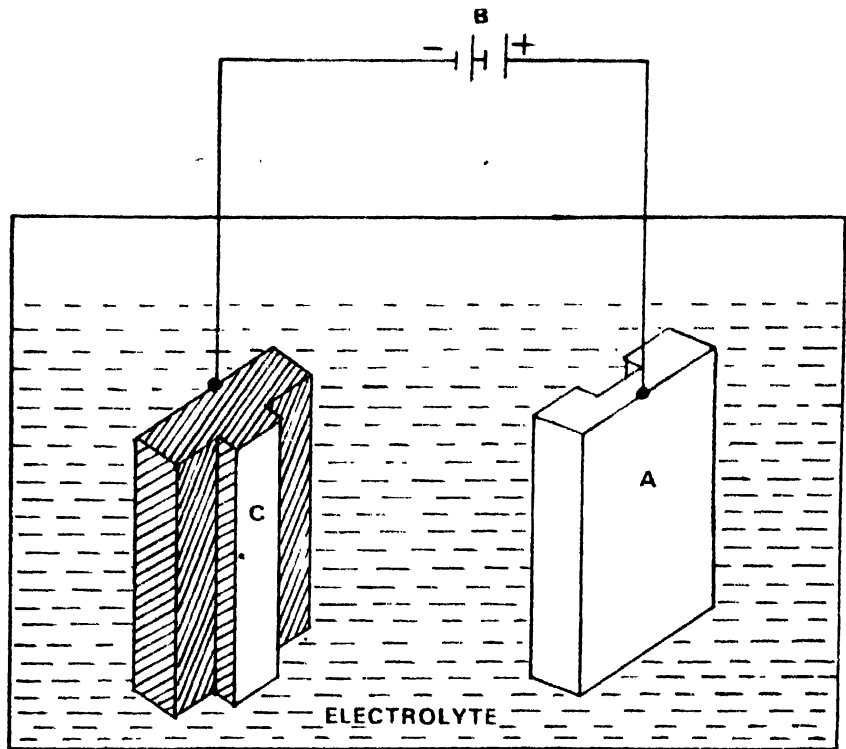


Fig. 1. Electrolytic cell; A. Anode; B. Battery; C. Cathode

is achieved by the controlled anodic dissolution of the workpiece by electrochemical reaction occurring in the electrolytic cell.

The metal removal rate is governed by the well-known Faraday's laws of electrolysis. The current that moves through the external circuit is carried by electrons, and that passing through the electrolyte by ions (electrically charged atoms molecules or molecular aggregates that have acquired a positive or negative charge by losing or gaining electrons). The anodic workpiece *A* carries electrons from the electrolyte into the external circuit while cathodic tool piece *C* moves electrons into the electrolyte (Fig.1). The chemical changes mainly occur at the electrode surfaces and are caused by the transfer of electrons between the electrodes and the ions.

The ECM process is similar to the electroplating process but differs in two respects. The latter utilizes cathodic deposition process whereas

the former is based on anodic dissolution process.

The development of ECM as an industrial process has been slow due to lack of proper understanding of the anodic dissolution process under high current density at different operating conditions. To achieve good control on the design of the tool that would eventually produce desired shape of the machined workpiece, a detailed knowledge of the performance of the electrolyte is required. This is necessary for determining the optimum tool feed rate to maintain a constant gap between the workpiece and the tool. High current density and a suitable electrolyte of high electrical conductivity are necessary for increased productivity.

### Factors affecting ECM operation

The operation of ECM is influenced by several factors. For better operation and economically

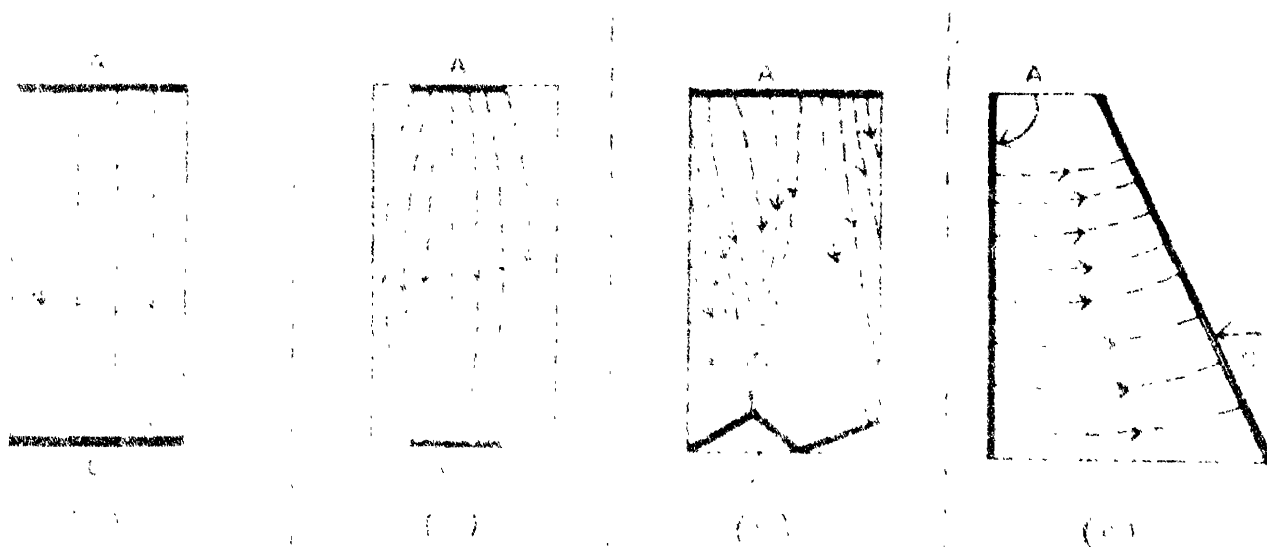


Fig. 2. Current distribution with different cathode shapes of an electrolytic cell; A. Anode; C. Cathode

high metal removal rates ( $\sim 0.003 \text{ cm s}^{-1}$ ), ECM is carried out under conditions of high flow rates of electrolyte ( $\sim 40\text{--}100 \text{ ml s}^{-1}$ ), high anodic current density ( $\sim 35\text{--}180 \text{ A cm}^{-2}$ ) and controlled operating voltage ( $\sim 5\text{--}15 \text{ V}$ ). The gap distance between the electrodes (anodic workpiece and cathodic tool) is maintained within  $0.005 \text{ cm}$  to  $0.1 \text{ cm}$  depending upon the finish of the machined surface, size and shape of the electrode and the nature of electrolyte. The machining time may vary from  $10 \text{ sec.}$  to  $1 \text{ min.}$  or even more depending upon the size, shape and finish required.

As the ECM process progresses, the gap between the anodic workpiece and cathodic tool varies from point to point with respect to time. The current density distribution

within this gap between the electrodes depends on their geometrical shape, distance from the electrolytic cell walls, nature of the electrolyte and the electric field strength. As the electric field strength at projected points of the cathode is inversely proportional to their diameter, the projected cathode areas always have a high current density than recessed areas. Further, the distance between the electrodes becomes smaller as the ratio of electrode diameter to the cell diameter is reduced. Consequently, maximum current density is obtained at the point where the anode-cathode separation is the least. Schematic representation of current distribution between the electrodes of different shapes is illustrated in Figs. 2a-2d. Uniform current distribution with parallel

electric field lines between the electrodes is obtained with a rectangular cell in which the electrodes completely cover the facing cell walls (Fig. 2a). When the electrodes are parallel but do not cover the cell walls completely (Fig. 2b), a distortion in the current lines takes place and the current density increases from centre towards the edges. Distribution of currents for other cathode shapes is shown in Figs. 2c and 2d.

#### ECM of hardened metals with complex shapes

To machine a hardened metal workpiece sample (anode) having complicated contours and shape (Fig. 3a), a tool (cathode) of complementary shape (Fig. 3b) is required. The current density and hence the surface dissolution of workpiece is maximum across projected points A, C, E that are nearer to points A', C', E' of the tool piece (Fig. 4). However, it is minimum across points B, D where gap is more. After some time, the workpiece sample acquires the desired shape corresponding to that of Fig. 3a and the current density becomes uniform at all the points of the work-

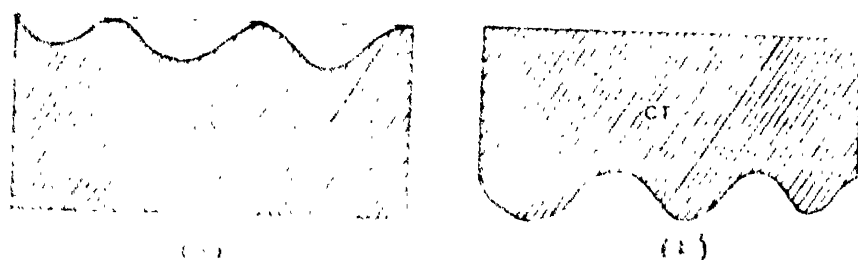


Fig. 3. AW. Anodic workpiece; CT. Cathodic toolpiece

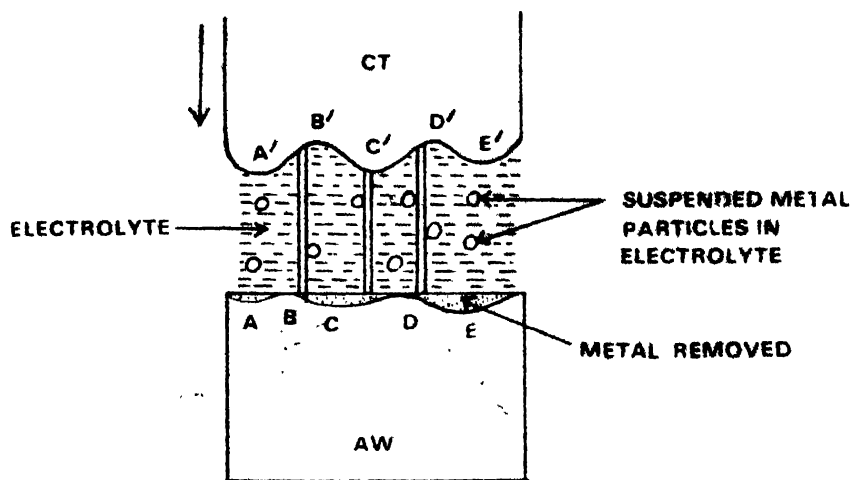


Fig. 4. Formation of contours in machined workpiece; CT.-Cathodic toolpiece; AW.-Anodic workpiece

piece. At this stage, however, the surface of machined workpiece is rough. To have the desired fineness and finish of the surface, the machining process is continued for more time.

As the ECM process continues, metal is removed from the anodic workpiece, widening the separation gap between the electrodes. This reduces the effective anode potential due to potential drop and therefore the current density over the surface

of workpiece is reduced. Also, this adversely affects the machining operations rate. In order to compensate for these changes, the gap between the tool and the workpiece must be maintained constant throughout the machining process by a mechanically driven feed system. For this purpose, the tool is fed and moved towards the stationary workpiece by means of a suitable feedback circuit.

Due to high current density, the ECM operation is always accom-

panied by a temperature rise, although confined to microscopic regions of the surface of workpiece. However, this causes no significant damage to the workpiece. To remove this extra heat, the electrolyte is transported through and circulated rapidly in the gap between the electrodes by means of a pump. A filtering device removes the metal sludge in the electrolyte, making its composition uniform and homogeneous throughout the ECM operation. Continuous circulation of the electrolyte between the electrodes serves two purposes. It serves as a stirrer to make the electrolyte homogeneous and also as a coolant to remove extra heat produced during the machining process.

### ECM of iron

For machining harder materials such as iron, nickel or steel alloys by ECM, a suitably shaped copper tool serves as the cathode and the workpiece (iron plate) as the anode. Any complicated contour can be produced on the work surface by suitably designing the tool. Generally, the gap between the electrodes (anodic workpiece and cathodic tool) is taken as 0.05 cm, although it may typically range from 0.005cm to 0.03 cm. The current density may typically range from 35 to 65  $A\ cm^{-2}$ . The electrolyte is usually a neutral salt solution such as sodium chloride, sodium nitrate, sodium chlorate. For electromachining of Ni, Fe or Ni-Cr alloys, excellent dimensional control and surface finish of a desired cutting geometry is possible only with sodium chlorate. With sodium chloride as electrolyte, undesired (stray, non-uniform) cutting occurs which eventually produces complete lack of dimensional control. Similarly, dimensional control using sodium nitrate or acids as electrolyte has been found unsatisfactory. For machining ferrous metals and hardened Ni-Cr-steel alloys,

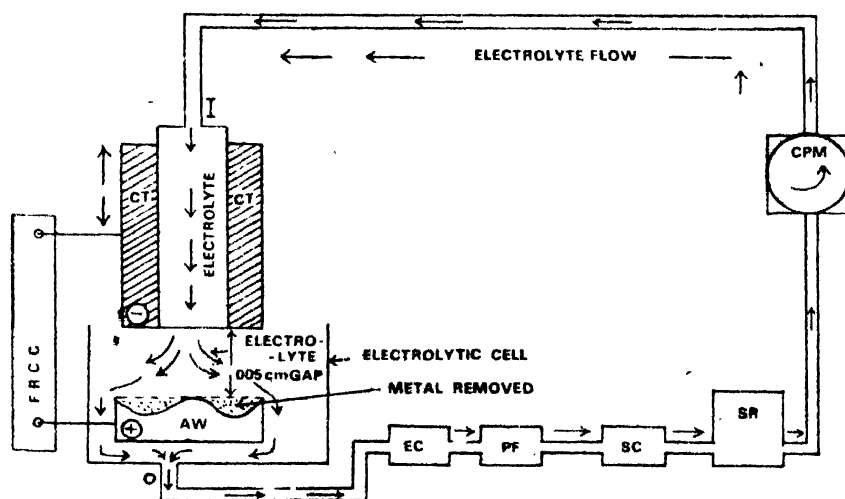


Fig. 5. Schematic illustration of ECM assembly; I. Inlet; O. outlet; CT Cathodic toolpiece (hollow tube); AW-Anodic workpiece; FRCC-Feed rate control circuit; CPM-centrifugal pump and motor; SR-Solution reservoir; SC-Solution concentrator; PF-Purifier (filter); EC-Electrolyte collector

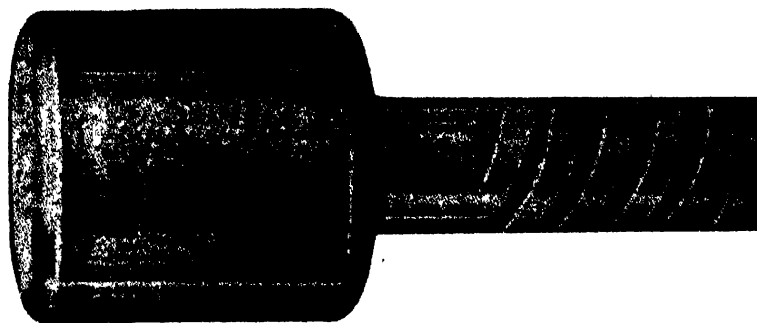


Fig. 6. Lead screw with shallow threads

sodium chlorate is a superior electrolyte. Metal removal rates as high as  $0.003 \text{ cm}^3$  at working current density of  $62 \text{ A cm}^{-2}$  have been achieved by applying potential of 8V between the electrodes. Under these conditions final finish of machined surface measured from 0.002 to 0.125 microns (1 micron =  $10^{-4} \text{ cm}$ ) in a machining time of 1 min.

Since chlorates and nitrates are generally potential fire hazards, sodium chloride is used as a base solution. Addition of sodium chloride with sodium chlorate also increases the dissolution of iron.

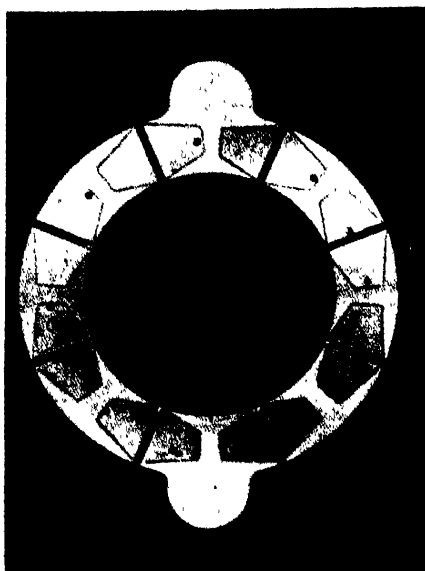


Fig. 7. Shallow and smooth oil pads of hydrostatic bearing

### Applications

ECM is a highly efficient and versatile process so that a considerable variety of machining operations can be accomplished. It can be employed for cutting threads in a steel shaft (Fig.6), machining of gears turbine blades (Fig.8) etching a groove in a metal panel by jet etching assembly etc. The rate at which metal is removed is not affected by the hardness of the workpiece. The process is applicable to any conducting material irrespective of its hardness, strength, chemical composition and microstructure. It is especially suited for machining hard materials such as tungsten, cemented carbides, nichrome (Ni-Cr-steel) alloy, hard non-ferrous alloys, super-alloys and steels. The process is attaining world-wide applications especially in industries such as nuclear power generation, aircraft and aerospace industries in which high-strength - temperature - resistant (HSTR) alloys are used.

As the workpiece and tool are never in physical contact with each other the distortion and wearing of the tool in ECM is minimum. So, one tool can be used much longer than in conventional methods. Any complicated shape or contours with high degree of surface finish can be obtained with a properly designed tool (cathode). Highly complicated

profiles and cavities can be machined quickly in fully hardened metal blocks by a single step operation of the ECM process known as 'die' or 'cavity sinking'. Also, it is possible to shape soft and brittle metals which are unsuitable for machining by conventional methods.

There are certain limitations of the ECM operation. When a metal is cut mechanically, its surface tends to be smeared out to a certain extent so that undesired compressive stresses are induced in the process. But the surface work hardening or induced

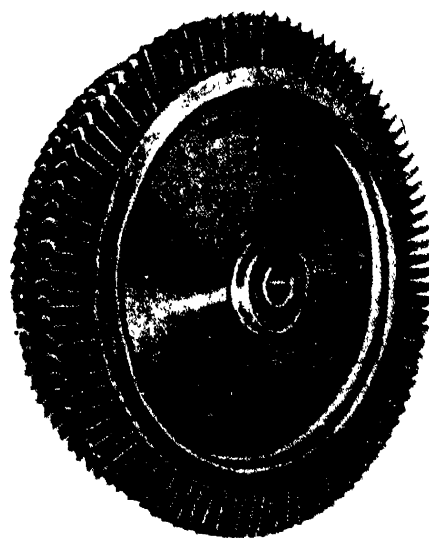


Fig. 8. Integrally-bladed turbine

stress tends to improve the fatigue lives (tolerance to cyclic compressive stresses) of components. In ECM, metal is removed atom by atom and so it is not subjected to such stresses. In certain electrolytes the surface fatigue properties of some materials may be altered by chemical attack at grain boundaries of the tiny individual crystals of the metal.

The ECM technique cannot be used for machining large areas as it involves high electrical energy consumption which is about 150 times that required for turning or milling steel. However, this high cost of energy is balanced by the

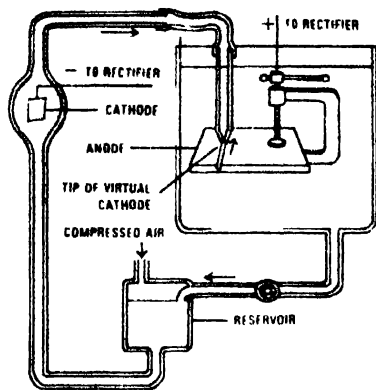


Fig. 9. Jet etching

many advantages of the process as compared to conventional methods. Sometimes, the method becomes expensive because considerable skill and time are required to design and shape the cathode and the electrolytic cell. However, the cost of tooling can be recovered quickly if many identical workpieces are to be machined in a single operation with greater efficiency and without any appreciable tool wear.

Considerable work has been done on ECM technology in the advanced countries like the U.S.A., Yugoslavia,

U.K. and Japan. In India, the Central Electro-Chemical Research Institute (CECRI) at Karaikudi (Tamil Nadu), Jadavpur University, Calcutta. I.I.T.s at Madras and Delhi have also initiated research on ECM. However, no significant results have so far been reported.

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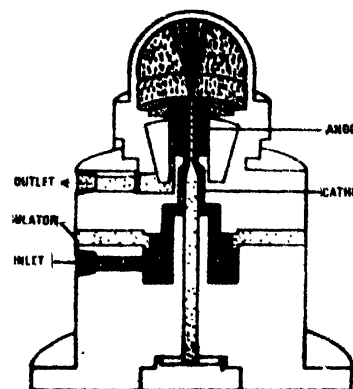


Fig. 10. Cross-sectional view of ECM assembly to finish a

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# ELLIPSOMETRY

## A NEW TECHNIQUE IN SURFACE SCIENCE

B. C. NAYAR  
ARTHUR W. ADAMSON

**Using the ellipsometric techniques, it is now possible to measure the exact thickness of a vacuum deposited layer on a metal surface or that of an adsorbed film on an adsorbent surface to a high degree of accuracy**

**F**OR many years scientists have been interested in knowing the exact thickness of a vacuum deposited layer on a metal surface or that of an adsorbed film on an adsorbent surface. Since the film thickness on these surfaces is extremely thin to the order of few Angstrom units, it was almost impossible till recently to measure it experimentally. However, in the last few years a new technique called "ellipsometry" has been so much developed that it is now possible to measure experimentally the thickness of a film with an accuracy of  $\pm 0.5 \text{ \AA}$ .

### Principle of ellipsometry

Ordinary light consists of electric (E) and magnetic (H) vibrations

taking place in all possible planes. For each E vibration the associated H vibration takes place in a plane at right angles to it. In plane polarized light the E vibrations are confined to one plane called the plane of vibration, and hence the associated H vibrations are also confined to one plane, called the plane of polarization. A plane polarized light can be circularly polarized in which the electric vibrations describe a circle about the direction of propagation of light axis. It can also be elliptically polarized where the electric vibrations describe an ellipse. These three situations of plane polarized, circularly polarized and elliptically polarized light are illustrated in Fig. 1 in a simple way.

The basis of ellipsometry is the

fact that the state of polarization is altered upon reflection from both plane and a film covered surface. From a clean, film-free surface the analysis of the elliptically polarized reflection can be used to determine the optical constants of the surface such as refractive index and extinction index. If, on the other hand, the surface is coated or covered by a thin film, ellipsometry can provide the optical constants and in turn the thickness of the film.

It was the German scientist Paul Drude who first introduced the two parameters characterizing the elliptically polarized light reflected from solid surfaces. One parameter is the amplitude ratio,  $\psi$ , i.e., the ratio of the magnitude of the reflection coefficient for light polarized in the

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plane of incidence to that polarized normal to the plane of incidence. The other parameter is  $\Delta$ , the relative phase difference for these two polarizations. Fig. 2 illustrates a thin film covered surface. The equation derived by Paul Drude is considered to be the fundamental equation of ellipsometry, which is given by:

$$\tan \psi e^{\Delta i} = \frac{(r_{pol} + r_{p12} e^{-2ix})(1 + r_{sol} r_{s12} e^{-2ix})}{(1 + r_{pol} r_{p12} e^{-2ix})(r_{sol} + r_{s12} e^{-2ix})}$$

$$\text{where } x = \frac{-\pi d(n_1^2 - n_0^2 \sin^2 \phi)^{1/2}}{\lambda}$$

$r_{pol}$  and  $r_{sol}$  = reflection coefficients for the ambient medium-film interfaces

$r_{p12}$  and  $r_{s12}$  = reflection coefficients for the film-solid interfaces

$n_0$  = refractive index of ambient medium

$n_1$  = refractive index of film

$d$  = thickness of film

$\lambda$  = wavelength of incident light

= angle of incidence.

What one measures in ellipsometry are the two quantities  $\psi$  and  $\Delta$ , and from these the thickness of the film,  $d$ , is calculated. Since the above equation is a highly complex one, its solution is done by a computer or programmed calculator. In fact it was because of the complexity of calculation use of ellipsometry was slow though the fundamental equation was known as early as 1890. With the development of high speed computers, calculations have become so easy that it is now possible to measure film thickness in a few seconds with an accuracy of a few Angstrom units.

#### Instrumentation

The ellipsometer is a high precision optical instrument which mea-

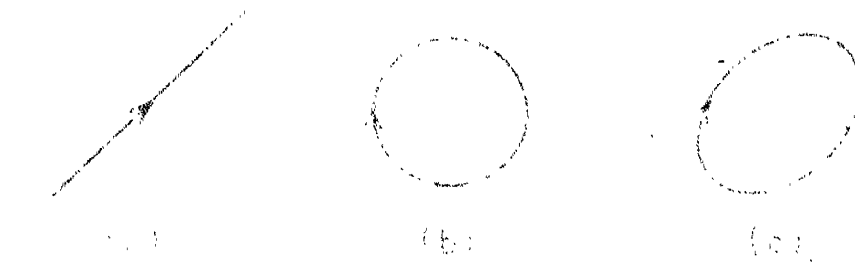


Fig. 1. Linearly polarized (a), circularly polarized (b) and elliptically polarized (c) states of light

sures the changes in the state of polarized light reflected from the surfaces of samples. In essence, it is a polarizing spectrometer. Since one makes use of elliptically polarized light, the name ellipsometer was introduced in 1944 by Alexandre Rothen while working at the Rockefeller Institute for Medical Research, USA. The essential parts of a typical ellipsometer are illustrated in Fig. 4. The photograph shows Type 436 research ellipsometer marketed by Rudolph Research, New Jersey.

Light from a monochromatic source (usually a high pressure

mercury vapour lamp or a He-Ne laser) is first filtered by a narrow band filter and then collimated by a collimator. The collimated unpolarized monochromatic light passes through a polarizer which is a Glan-Thomson polarizing prism. In the polarizer light gets linearly polarized which then goes through the compensator. The compensator consists of a mica plate selected for quarter wave retardation and it is here light gets elliptically polarized. There is a variable aperture incorporated in the compensator permitting the diameter of the collimated light beam to be varied.

Fig. 2. A thin film covered sample surface

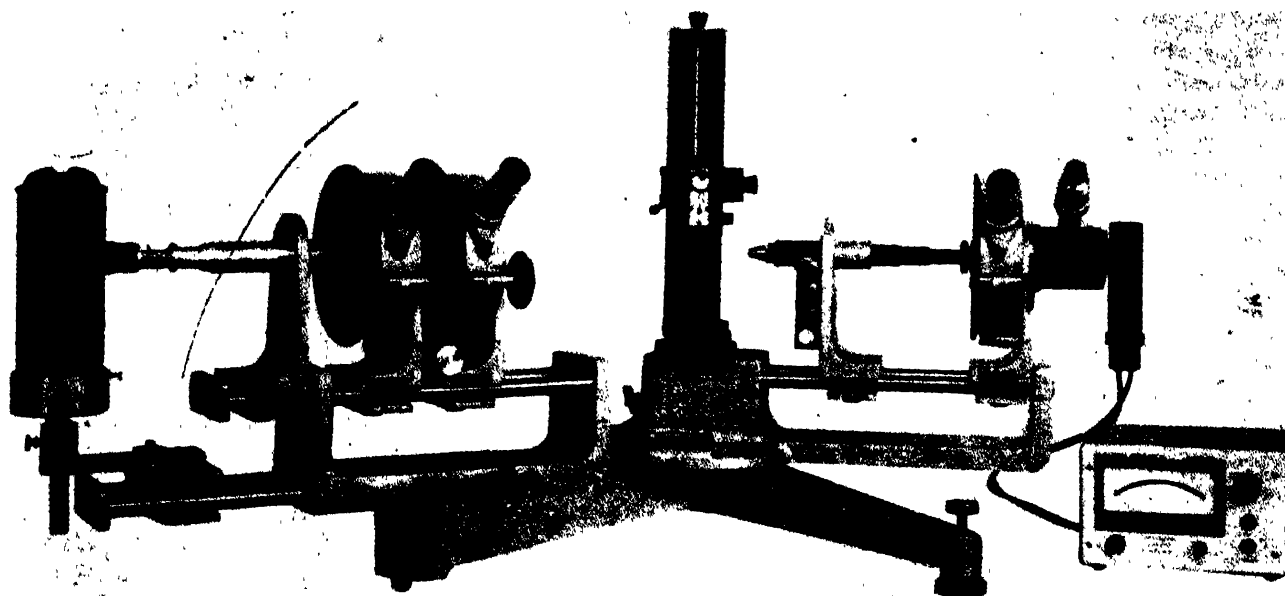


Fig. 3. A typical research ellipsometer (Courtesy: Rudolph Research, New Jersey, U.S.A.)

The elliptically polarized light is then directed to the specimen sample (substrate) to be studied in the sample mount. After being reflected from the sample surface, light gets linearly polarized again and passes through an interchangeable aperture to the analyzer. The analyzer is similar to the polarizer in optical construction. The housing of the analyzer also incorporates a telescopic mirror which allows visual observation, and a photomultiplier tube. The intensity of light striking the cathode of the photomultiplier tube is read by the photoelectric intensity meter.

#### Method of measurement

In practice, the method of measurement in ellipsometry is quite simple. What one does is to rotate the polarizer and analyzer keeping the compensator fixed at an angle till one gets an extinction of light as indicated by a minimum reading in the photodetector. The readings are taken for the bare surface covered by a thin film. From these readings of the analyzer and polarizer one can calculate by a computer the

film thickness using the Drude equation given earlier.

#### Application of ellipsometry

Ellipsometry is a powerful and sensitive method in the measurement of thin films, and is applicable in a wide variety of situations. The measurements can be performed upon specimens in normal air and other gaseous environments, in vacuum, and on or under liquids. Depending upon the light source used and the optical parts of the ellipsometer, measurements can be performed at any wavelength from the ultraviolet to the far infrared. The technique is sensitive enough to measure changes in film growth down to less than one Angstrom unit, and is completely non-destructive. We will now discuss some of the important applications of ellipsometric technique in industry and research.

#### Semiconductor process control

The thickness and composition of dielectric layers used in silicon based microcircuit devices are of

great importance to the semiconductor industry. These thin dielectric layers determine the performance and reliability of integrated circuit devices. Even small variations in silicon dioxide layer thickness across the silicon wafer will affect the sensitivity of the device. The thickness of the dielectric layer on a semiconductor surface can be effectively measured and controlled by the use of an ellipsometer.

#### Electrochemical research

Ellipsometry is an eminently suitable technique for studying the formation and growth of anodic films. A knowledge of the adsorption behaviour of organic molecules on the surface of electrodes is extremely important in electrochemical studies. Ellipsometry now accurately measures the thickness of an adsorbed layer on an electrode surface in a solution. In addition, the variation of adsorption with potential can also be followed ellipsometrically. In electroplating industry, the thickness of electrodeposited layers on a variety of metal and plastic surfaces can be studied by ellipsometry.

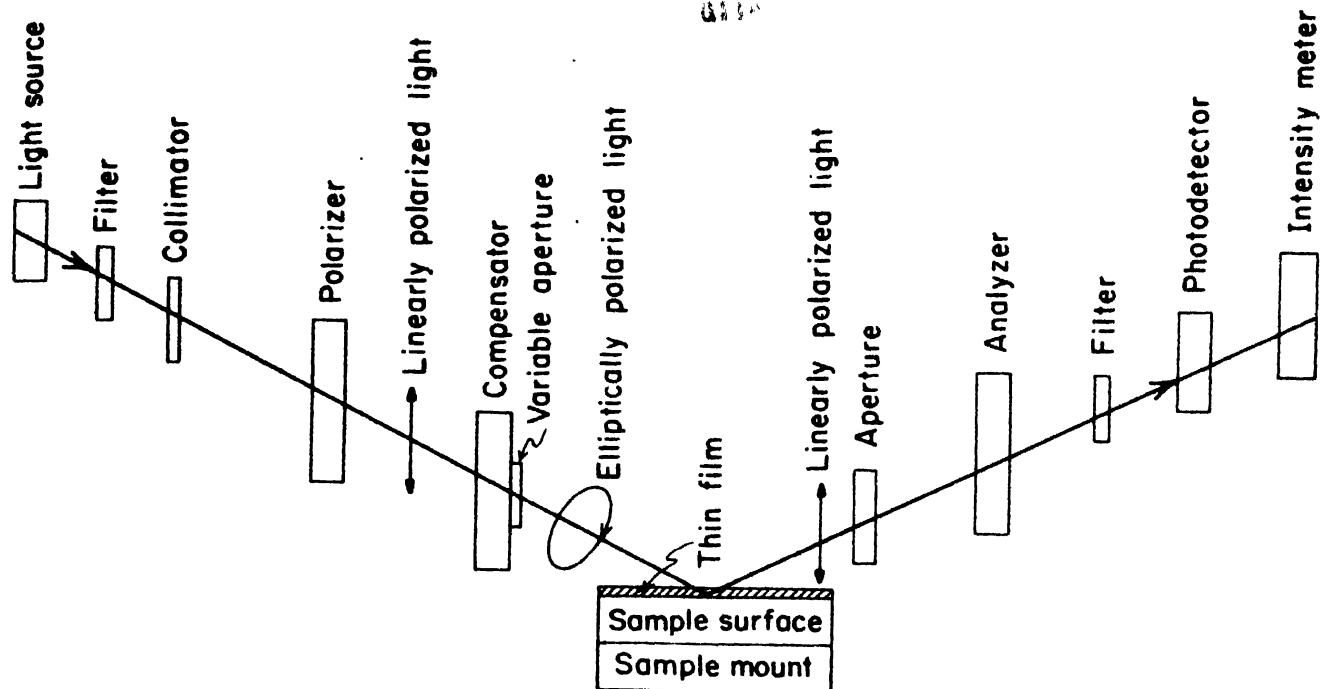


Fig. 4. Schematic illustration of ellipsometer components

### Surface chemistry

Until the development of ellipsometry, it was not possible to directly measure the thickness of a physically adsorbed layer on an adsorbent surface. In studying physical adsorption, knowledge of the thickness of adsorbed layer is of fundamental importance and now with the use of an ellipsometer, the thickness of adsorbed layers of a wide variety of gases and vapours on different surfaces ranging from metals to plastics have been studied and reported in the literature. Fig. 5 illustrates the construction of adsorption isotherms by measuring the film thickness of carbon tetrachloride on stainless steel and n-hexane on chrome plated glass as typical examples. Such studies have contributed greatly to our already existing knowledge of physical adsorption, contact angle and wetting.

Adsorption of oil soluble surfactants on metal surfaces from organic solutions have been ellipsometrically

studied. Similar studies on the effects of gasoline, oil additives and lubricants on moving parts of internal combustion engines through ellipsometry are of practical significance.

In chemisorption, a knowledge of the thickness of adsorbed layer is desirable in understanding the reaction mechanisms of metal catalysts used in almost all heavy chemical industries. Such studies are now being carried out through ellipsometry.

Some measurements difficult or impossible to make by other techniques include phenomena on surfaces in ultra high vacuum, on surfaces immersed in solutions, and on surfaces at elevated temperatures and pressures.

### Metallurgy

Ellipsometric studies in this field include monocrystalline and polycrystalline metallic surfaces, oxidation and corrosion processes on such surfaces, and techniques and mate-

rials for the protection of surfaces. Studies have been carried out on: oxides and other films formed on aluminium, silver, tantalum, titanium-aluminium alloys and tungsten, and the properties of thin oil films on steel sheet and tin plate.

### Optics

Ellipsometry is useful for the study of reflective, antireflective and wavelength-selective films on optically transmissive substrates especially during vacuum deposition. Ellipsometry is perhaps the only known technique for study of the polish layer formed on the surfaces of optical components by the polishing process.

### Medical research

New ellipsometric techniques have been developed for studies of blood coagulation, immunological reactions, viruses, and adsorption, interaction and exchange of specific plasma

(Continued on page 321)

Indiscriminate use of poisonous pesticides can cause serious damage to environment and even endanger human life



# THE PESTICIDE THREAT

**L**IVING organisms such as insects, weeds, rodents, fungi, which compete with man for food and which causes destruction to domesticated animals and plants or pose public health hazards are called pests, and chemicals used to control them are pesticides. Pesticides also include insecticides, herbicides, fungicides, weedicides, and rodenticides.

Success with these chemicals during and after the World War II was impressive both in the developed and the developing countries. Today about 1000 pesticides are in use in the world. About 250 are used in agriculture, of which 100 are insecticides, 50 herbicides, 50 fungicides, 20 nematocides and 30 other chemicals.

It is now being increasingly realised that pesticides have some undesirable side effects and cause environmental pollution. Among the pesticides normally used are those belonging to the organochlorine family such as D.D.T., aldrin, dieldrin, etc., which have attracted much attention and criticism for their adverse effects on the environment.

D.D.T. as a pesticide has been used to kill insects that destroy crops and which carry and transmit such diseases as malaria and plague. Use of D.D.T. has improved the economic, social and health status of underdeveloped and developing countries. For example, it curbed malaria in India and Pakistan, and plague in Dakar. It has been estimated that during the first ten years of use, D.D.T. saved about five million lives and prevented 100 million from illnesses such as typhus, malaria, dysentery and more than twenty other insect-borne diseases. In the last ten years, the use of D.D.T. in India alone has increased nearly four times. But the situation is somewhat changing now. Today, man is more conscious about his environment than he was in early forties. What were thought to be the special assets of D.D.T. and other pesticides have only served to mask their disadvantages.

#### Background of Indian pesticides industry

Use of pesticides in India started only after independence, and the first plant to produce a pesticide (BHC) on a commercial basis was set up in 1952 and the first public sector D.D.T. plant came into existence in 1955. The use of pesticides in agriculture began slowly with the realisation they were necessary for crop production. The consumption of pesticides increased from 3,750 tonnes per annum in 1952 to 25,000 tonnes in 1957 and 45,000 tonnes in 1962. The total requirement of technical grade pesticides for 1978-79 for agriculture has been estimated at 77,420 tonnes. At present, India is manufacturing and formulating 44 types of pesticides in 86 units of which 42 per cent are situated in Maharashtra. The Hindustan Insecticides Ltd. (HIL) incorporated in 1954 with manufacturing units at Delhi is to start one more unit at Rasayani for the production of D.D.T.

## Resistance to pesticides

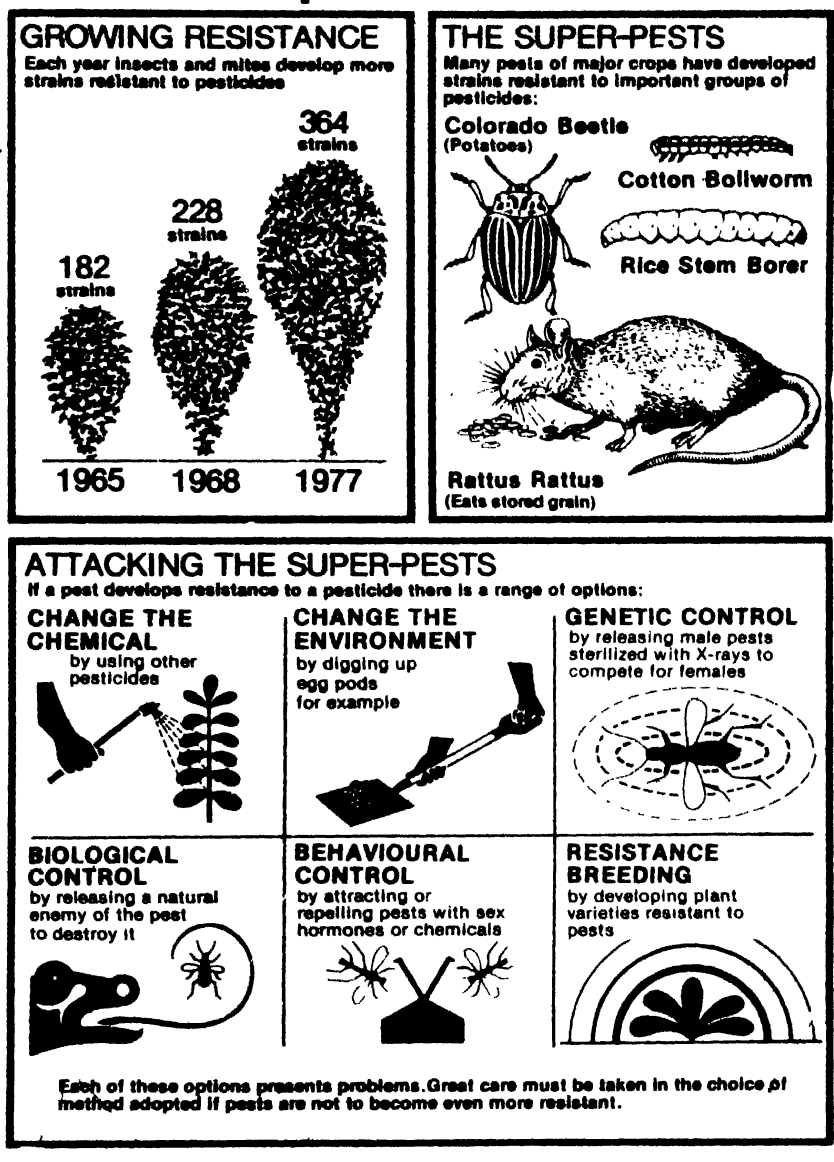


Fig. 1

#### Pesticides concentration in the environment

With the introduction of pesticides to control pests and vector-borne diseases, there has been a rapid increase in the use of insecticides, herbicides and fungicides. Some chemicals used for this purpose are toxic to a wide range of animals including man. A pesticide residue

which accumulates in soil forms a part of the problem of general contamination of the environment. A high proportion of the pesticides used in India is applied on crops and only a small quantity is used for soil and seed treatment. Soil pollution may become serious with the persistent use of insecticides like aldrin, D.D.T. and endrin over a number of years. It is believed that a number of

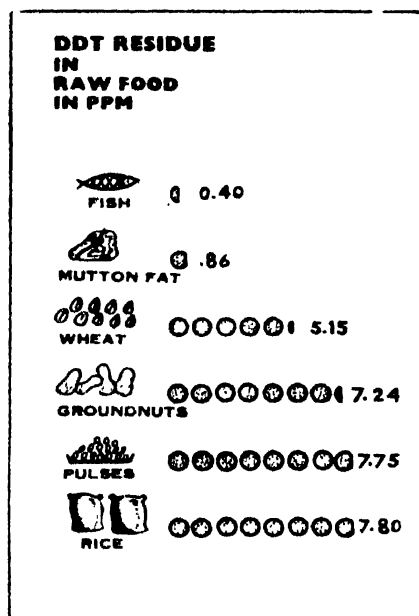


Fig. 2

birds are facing extinction because of the use of D.D.T. and other pesticides. The presence of pesticides in food, water, air and crops is attributed to the wrong manner of their handling.

#### Pesticides in food

Surveys made in India to estimate the residues of pesticides in market samples of different food items showed that D.D.T. contamination was around 91.7%. In another survey, D.D.T. in the range of 8-83 ppm was found in 36 samples out of a total of 120. According to a recent report, the use of pesticides on crops and vegetables appears to be excessive, uncontrolled and without consideration for the health of consumers. Vegetable growers spray pesticides indiscriminately not only during the growth of vegetables but also at the time of picking them. Spraying at the time of picking is done to give them a fresh look. Detailed studies at the Punjab Agricultural University have confirmed that cauliflower is unsafe to market unless it has been plucked at least 10 days after

the last spraying. Almost all the samples of edible grain analysed showed pesticide contamination. Samples of wheat, maize and *bajra* contained invariably high levels of D.D.T. besides other insecticides. The analysis of various pesticides is done by several institutes including the Central Food Technological Research Institute, Mysore and the Indian Agricultural Research Institute, New Delhi.

Reports on the residue analysis of milk samples reveal that out of 17 samples analysed 13 contained D.D.T. at levels ranging from 0.02 ppm to 0.75 ppm. D.D.T. content was above tolerance level of 0.05 ppm in 55% samples. D.D.T. residues in various samples of branded butter carry from 1.1 ppm to 8.0 ppm. Eggs, in contrast to milk or butter, are found to contain low levels of D.D.T. The level of contamination in food is given in Fig. 2.

According to one estimate, an average daily Indian diet contains about 0.27 mg of D.D.T. The levels of D.D.T. in human fat samples from Delhi appear to be the highest of all the surveys done so far in the world. It is interesting to know that fat samples collected and analysed from different regions of India such as Delhi, Kanpur, Ambala, Jabalpur, Pune and Bombay contained D.D.T. Civilians in Delhi area with relatively no occupational exposure to D.D.T. had higher levels of D.D.T. in their fat than comparable persons in the United States, but the level of D.D.T. in the fat of Indian military personnel was comparable to that in military personnel in the United States.

D.D.T. poisoning is acute due to its immediate effects, and is chronic due to its proneness for storage in liver and other organs. Kerosene oil in which it is ordinarily mixed and sprayed is itself a poison with the ability to steal the important vitamin 'A' from the liver where it is stored.

How does D.D.T. act on human system? After eating food containing D.D.T. one part in a million, one develops dryness of the mouth. This leads to the conclusion that the insecticide is absorbed from the small intestine where fats are digested. With dry mouth there develops a roughness of the mucous membrane lining. With a more concentrated dose sometimes a blister forms. If the food is consumed at night, the poison causes nightmarish dreams from poisoning of the forebrain-seat of visionary conception. Sleep gets disturbed for hours. Eyes feel dry and gritty, an usual symptom of vitamin 'A' deficiency.

In connection with the spraying of grains and vegetables by D.D.T., scientists of the Industrial Toxicological Research Centre, Lucknow, have strongly advised that whole wheat, before being sent for grinding, should first be washed and dried thoroughly in the sun. It is advised that pulses should be washed several times before cooking, and so also all vegetables and fruits.

#### Pesticides in air

During manufacture, packing and applying a pesticide, workmen receive significant exposures. Poisoning effects can be expected to appear quickly in those persons who are most extensively exposed. Pesticides also enter atmosphere by way of direct spraying operations (Fig. 3).

Metal cans are very much in use in developing countries like India. People, especially in rural areas use empty insecticide cans for storing food. Some even use the poison as a hair spray to kill lice in their hair. The large quantity of D.D.T. fat is attributed to the practice of spraying it inside of homes in India.

#### Pesticides in soil and water

A number of pesticides in India are used on standing crops. Soil



Fig. 3. Pesticide spraying in progress

contamination becomes serious when they are used for soil drench over a number of years. The extent of movement of pesticides in soil may depend upon the nature of pesticides, soil moisture, temperature, acidity, volatility, organic matter content, etc. Residue of pesticides may have adverse effects on soil micro-organisms, and therefore on soil fertility.

About 34,000 tonnes of pesticides and insecticides are used in agriculture and 1,10,000 tonnes of synthetic detergents are consumed for washing and cleaning purposes in India every year. 25% of these chemicals can be expected to find their way into the coastal marine environment. The region just off Bombay and near Bombay High is the most polluted area (1.44 mg/litre to 2.44 mg/litre). The amount of D.D.T. present in samples taken between Bombay and

Goa is quite disturbing; the D.D.T level varies from 0.05 ppm to 34 ppm. Although exact statistics is not available, it is estimated that 90 million hectares of land face soil erosion problems. Erosion by water constitutes the most severe menace to the land resources of the country, not only because it denudes soil directly but also because it leads to siltation of reservoirs and occurrence of floods. It has been estimated that the amount of soil displaced by water

erosion is in the order of 60,000 million tonnes per year.

This soil material moves into rivers and tanks and causes water pollution and hazards to human and animal health. Only a few years back, a disease known as *Handigodu*, named after the most affected village, was observed in the rural areas of Chikmagalur and Shimoga districts of Karnataka. The disease, believed to be caused by pesticides, leads to severe pain in hip and knee joints,

Table 1. Estimated population and area under cultivation

Year	Population (Million)	Area under cultivation (Million hectares)
1979	638.8	100
1984	685.8	120
1989	705.2	140



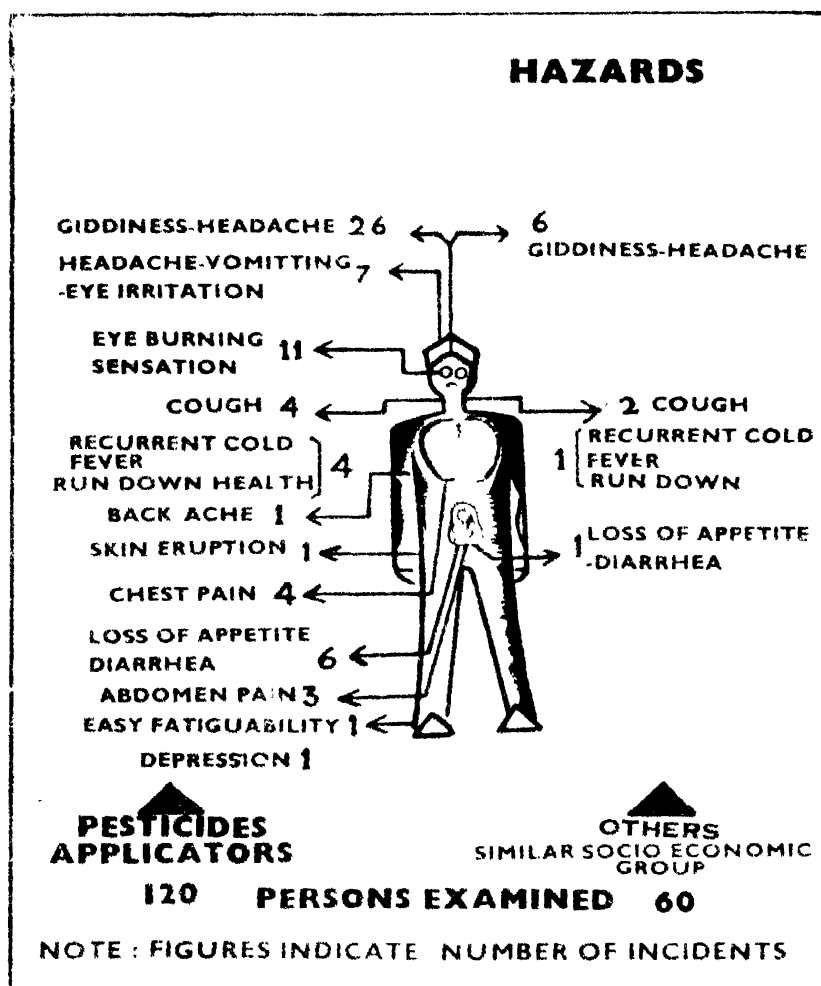


Fig. 4

abnormal growth of several bones, changes in the hip joint and in some cases changes in the femoral head. Both Chikmagalur and Shimoga districts grow paddy and coffee. Pesticides are extensively used there. Over 85% of the affected persons were Harijans, the rest were from the labour and poor class. Not a single case was found in Brahmins and landlords. Harijans and farm labour ate fish, frogs and crabs and ingested pesticides and suffered. Fig. 4 gives the increased rate of illnesses because of poisonous pesticides.

#### Future trend

In view of the imperative need of

India to increase food production, pesticides application within the country will further increase. Planners have estimated that population of this country will reach the region of one billion by 2000 A.D. The estimated population and increase in area under cultivation is given in Table 1.

With the present dosage of 570 grams per hectare, the estimated requirement works out at 77,420 for 1978-79. With the increased area from 100 to 120 million hectares, the total requirement of pesticides would be 1,39,000 tonnes of pesticides. Projecting consumption further and increasing the area under plant protection from 120 million hectares to 140

million hectares and achieving a level of 1000 grams of pesticides per hectare, the country would be requiring 1,87,000 tonnes of insecticides by 1988-89.

This estimated demand does not take into account the public health requirements as estimated by the Ministry of Health. However, it is estimated that D.D.T. requirement alone during 1985-86 would be twice the present requirement.

The estimated requirement of pesticides for the year 1978-79 is given in Table 2.

Keeping in view the expansion of pesticide industries, environmental pollution is a matter of utmost concern. Countries like the U.S.A. and Canada have already banned some pesticides including D.D.T. In order to ensure safety of human beings, animals and environment, the Government of India has already enacted Insecticides Act, 1968. The Act is expected to control manufacture, distribution and use of pesticides so as to avoid environmental hazards. It seems that government has not been able to enforce the Act properly.

India is one of the few countries in the world where the use of D.D.T. or PCBs have not been banned. The cost factor remains one of the reasons for India not banning the use of DDT and PCBs despite dangers from them.

#### Proper and safe application of insecticides

The old saying "If little is good, more is better" does not apply in the

Table 2. Pesticides requirement for 1978-79

	Tonnes
B.H.C.	9000
D.D.T.	7500
Malathion	1500
Diazinon	5
Miscellaneous	200

case of insecticides. Certain safeguards are needed to protect consumable items and consumer himself. When applying insecticides inside homes, we have to be sure that no food lies exposed. Unused insecticide should be kept out of reach of children. Empty containers should not be used for other purposes. Strict precautions should be taken at the time of application. Farmers and other operators should wear gloves,

goggles, gum-boots. To avoid pesticide residues, food crops should be harvested at the recommended interval after the last application.

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## ELLIPSOMETRY (Continued from page 315)

proteins at liquid/solid interfaces.

Many other studies apart from those described above have been carried out using the ellipsometer. These include detection and measurement of contamination on metal and glass, monitoring protein growth, crystal and mineral surface analysis, thermal oxidation kinetics, measurement of air flow birefringence, sub-microscopic on aluminium, etc.

Thus it can be seen that ellipsometry is potentially a new powerful and elegant technique with many applications in physics, surface chemistry, electrochemistry, metallurgy, engineering, electronics, biochemistry and medicine. However, like any other technique, there are limitations to the ellipsometric method too. It applies specifically to flat, smooth and reflective surfaces only. Not all surfaces can be made flat, smooth and reflective, though opaque films are now measured by changing the light source to Ir-CO<sub>2</sub> lasers which make the film transparent enough to be measured ellipsometrically. Films which are thicker than about 2,000 Å need to have the thickness range approximated by some other method before ellipsometry can give exact result. Though experimental measurements are quite simple to perform, ellipsometry is

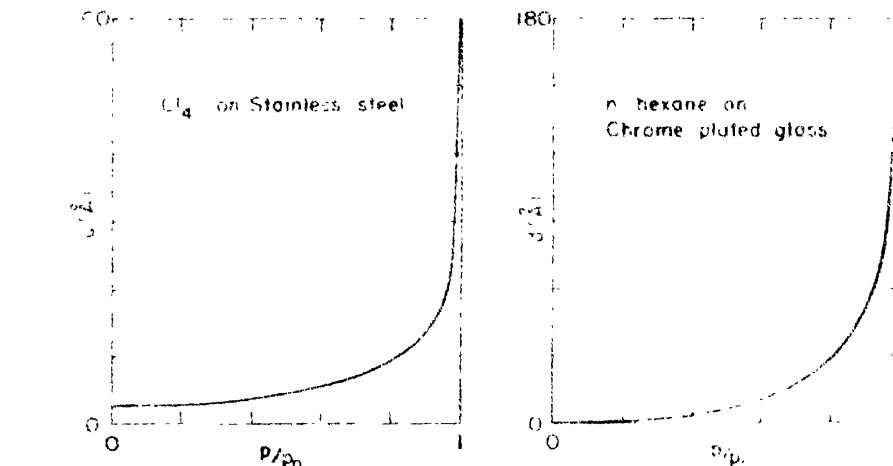
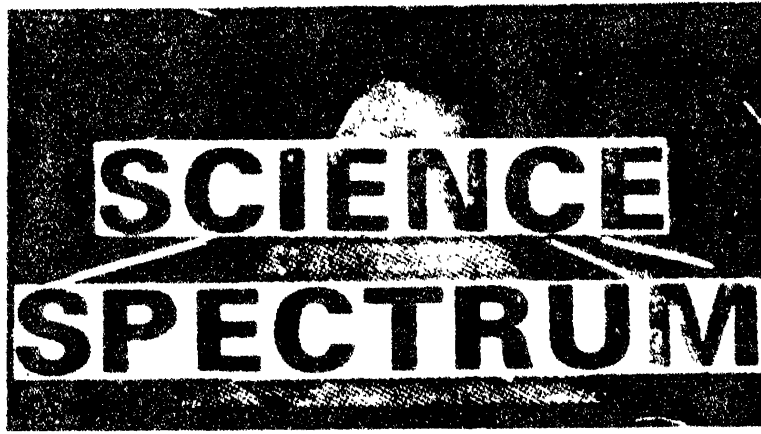


Fig. 5. Adsorption isotherms (relative vapour pressure vs. adsorbed film thickness) of carbon tetrachloride on stainless steel and n-hexane on chrome-plated glass

more often limited by interpretation and computation of the data obtained. However, with the introduction of automatic ellipsometers in the last five years or so, measurements can be made within a second and film thickness computed in less than four seconds. Modern instruments offer "push-button" operation so that anybody with a minimum training can operate. Accuracy of automatic ellipsometers is also claimed to be ten times better than that of manual units. It is reasonable, therefore, to expect that uses and applications of ellipsometry in all fields of science and technology will continue to expand.

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## Every comet has a spinning nucleus

**D**ISCOVER a comet and become immortal! This is the motto in astronomy, and could as well be called a sacrosanct understanding among astronomers. Rarely is this understanding violated. In this article the case in point is of Comet Encke, and the spinning of cometary nucleus is in no small way related to it. In 1786 Pierre Mechain discovered Comet Encke, but the comet was not named after

him. It was named after the mathematician and physicist Johann Franz Encke, who, 30 years later, predicted correctly that the movements of the comet do not go by the Newton's law of gravitation. This rare honour deserved his finding because however the astronomers tried they were not able to explain away the wild behaviour of the comet. Only recently the so-called mystery of the comet's

behaviour has been solved. Fred L. Whipple, a well-known authority on comets, and his colleague Zdenek Sekanina of the Smithsonian Astrophysical Observatory, U.S.A., have shown that this behaviour of the Comet Encke, which has now been found among many other comets, is due to the spinning of the comet's nucleus (*Scientific American*, March 1980).

In the time of Encke and even in the present century, astronomers had some funny notions about a comet, which was mostly the reason why they were unable to explain the wild behaviour of Comet Encke. It was then believed that a comet was a swarm of bodies of varied sizes somehow staying together in its orbit round the sun, and the wild behaviour was even attributed to the resistance medium in space—the proverbial ether! It was Fred L. Whipple who gave a crystal clear picture of the kind of object a comet is when he called it a dirty iceberg.

A comet is now considered to be a chunk of icy substances, which also contain traces of dust and many compounds. As this chunk of matter approaches the sun, its icy substances start evaporating and form a tail,

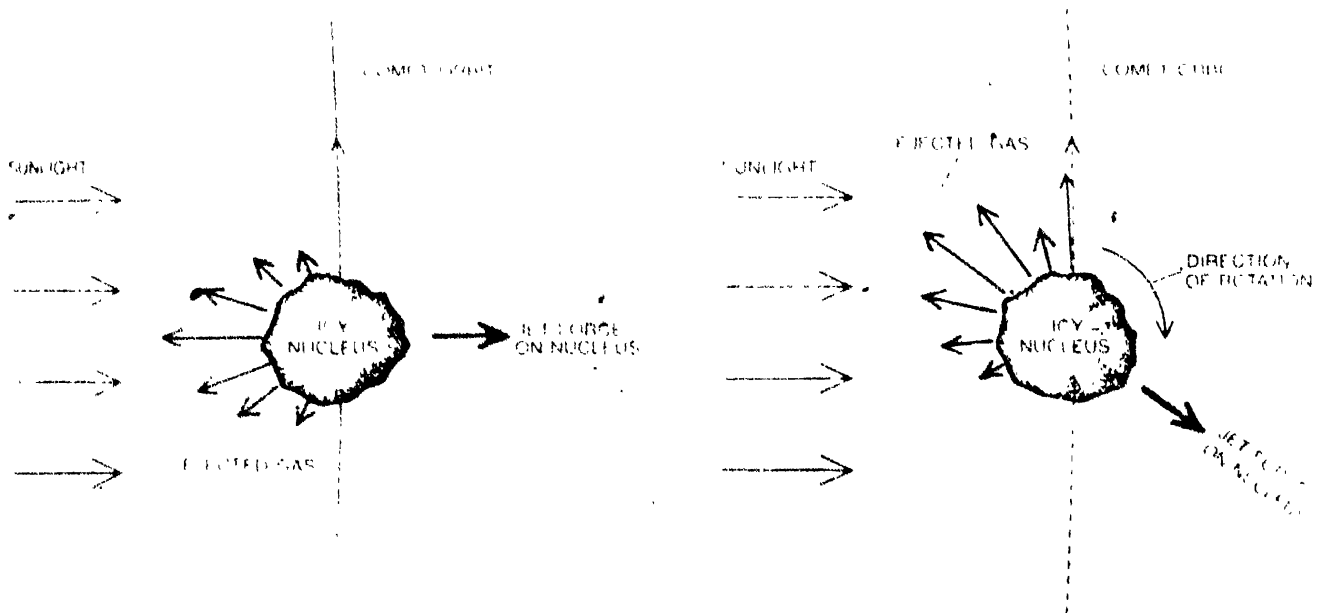


Fig. 1. Illustrations show how the reactive jet force would be like when the nucleus is not spinning (left) and spinning (right).



Comet Kohoutak as seen on January 15, 1974 (Courtesy : US ICA)

which grows bigger with lessening of distance from the sun. The tail always points away from the sun due to the solar wind, a stream of charged particles, the latter releases, just as the tail of a kite blows away in the direction of the wind. At a particular point in its orbit the comet takes a turn and moves away from the sun. This point of closest approach to the sun is called perihelion. Where do comets come from is difficult to ascertain. One thing is sure: they mostly come from outside of the solar system. Some comets are, however, called periodic comets because they return to the sun after a fixed interval of time, for example, the period of Comet Encke is 3.3 years,

the famous Comet Halley 76 years.

As comet Encke visits the sun every 3.3 years, astronomers have found in it a valuable object to throw light on comets as a whole, and so its behaviour has been studied more extensively than those of other comets. It has been found that the comet's period of revolution is decreasing. In other words, during every revolution the comet comes earlier than the calculated time. The rate at which the period of revolution is decreasing is also decreasing, even today. In the last 200 years it has decreased from  $2\frac{1}{2}$  hours to a few minutes. This anomaly was attributed to the reduction in jet force (Fig. 1).

It is apparent that when sun evaporates the icy material of the comet, a reactive jet force is produced in the opposite direction, in accord with the Newton's third law of motion. So it was believed that the jet force was getting reduced either due to loss of icy matter or due to accumulation of dust. However, this explanation could not account for the behaviour of the comet prior to 1810, when the period of revolution was increasing.

Using computers Fred L. Whipple and Zdenek Sekanina studied the movements of the Comet Encke in three dimensions. They arrived at the conclusion that Comet Encke, or for that matter any comet, has nucleus that spins affecting the geometry of the jet force, which, in turn, causes discrepancies in its motion. According to their calculations, Comet Encke has oblate shaped nucleus two Km in size embedded at its center. The nucleus is spinning about an axis which lies in the plane perpendicular to that of the orbit of the comet. When the direction of spin of the nucleus is opposite to that of its motion, the speed of the comet gets reduced, the result of which is that orbital path is reduced. The comet arrives at perihelion earlier than expected. The reverse direction of spin causes the comet to arrive later than expected. The reason why there is variation in the arrival times of the comet at every revolution is because the nucleus is gyrating like a spinning top, one thing; it is losing mass during every visit to the sun, secondly; and lastly its rate of spin is also decreasing. In the last 191 years the spin axis of Comet Encke has gyrated more than 100 degrees; it loses about 650,000 metric tons of matter during every visit, which comes out to be about one per cent of the total mass of the comet; and it is losing 20 to 40 minutes every century in  $6\frac{1}{2}$  hours of spin speed. The last result is based on the photographic study of the Comet Encke.

The way the Comet Encke gradually brightens up as it approaches the sun,

and thereafter dims abruptly is also puzzling. Astronomers believe that icy material evaporated on the sun-facing hemisphere of the comet accumulates on its other hemisphere, which results in the observed behaviour. Whether such a process is really happening on a comet can only be tested if a space probe examines it at close quarters. In 1984 the National Aeronautics and Space Administration and the European Space Agency plan to send two space missions, one to fly by the Comet Halley in 1985 and ano-

ther to examine Comet Temple-2 three years later. Besides looking into the aforementioned matter the space probe would also tell about the kind of material a comet contains. Comets are a subject of tremendous interest because it is believed that they are the direct "untouched" remnants of the gaseous cloud that formed the solar system. In recent times, a theory also claims that they may be the harbringers of life and disease on a planet like earth.

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## X-ray effects in frog

**R**ADIATION biology had its start in the year 1895, with the discovery of X-rays by the German Professor Wilhelm Conrad Roentgen. Shortly after the discovery of X-rays, it was realised that ionizing radiation, in the course of dissipating its energy on biological system, could produce many profound changes in structure and function of the organisms.

Frogs (*Rana hexadactyla*) exposed to

different doses of X-radiation showed dose-dependent mortality. Frogs exposed to a dose of 2800 r showed 50% mortality, 15 days after exposure. Following X-ray exposure, animals showed symptoms of acute radiation sickness, which resulted in haemorrhages, degeneration of vascular tissues, inactive movements, inhibition of feeding activity, etc. Animals lost eyelid reflexes leading to complete loss of visual recognition which might be due to damage to lens and retinal elements. Another change observed

was the blackening of skin in different regions on the dorsal surface of the animal. These areas turned pale leading to ulcerative necrosis (Fig. 1). Degenerative changes in skin involves noticeable loss of cells. X-rays were reported to produce abnormal development of embryos, inhibition of limb regeneration development of secondary tails, etc., in several amphibians.

Different explanations have been offered for the occurrence of radiation sickness. One such explanation is the release of toxic substances from disintegrating cells killed by the impact of radiation. Prominent among these are histamine and histamine-like products which are known to be mildly toxic. Other possible "poisons" formed by radiation are ammonia, hydrogen peroxide and some cellular decomposition products.

Death from X-radiation occurs either due to damage to hematopoietic system or intestinal tract or central nervous system. The organism can escape death if damaged cells manage to recover or if normal cells from similar organism are grafted.

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Fig. 1. Photograph showing tissue degeneration and damage to eyes in frog, *Rana hexadactyla* following X-ray exposure (2800 r)

## Onion skin—an excellent scavenger for heavy metal ions

**M**ANY industries such as non-ferrous metals, pigments, storage batteries, metal processing, finishing and plating discharge heavy metals in their waste streams (Table 1). Measurable concentrations of these metals are present in domestic wastewaters even in the absence of significant contamination with industrial wastes. Although

trace amounts of some of these metals are required in plant and animal nutrition, excessive amounts can be toxic. The safety limits of some of the toxic heavy metals in effluents for supporting aquatic life are given in Table 2.

Several methods have been used from time to time for heavy metal decontamination. Precipitation ion-

**Table 1. Heavy metals found in the waste streams of some major industries**

<i>Industries</i>	<i>Metals found</i>
Basic nonferrous metal works, Foundaries	Al, Ag, As, Cd, Cr, Cu, Pb, Sb, Zn
Basic steel works, Foundaries	As, Cd, Cr, Cu, Fe, Hg, Pb, Ni, Sb, Sn, Zn
Textile mill product	Cr
Leather tanning, Finishing	Cr
Pulp, Paper mills, Paperboard, Building paper board mills	Cr, Cu, Hg, Pb, Ni, Zn
Fertilizers	Al, As, Cd, Cu, Cr, Fe, Hg, Mn, Pb, Ni, Zn
Motor vehicles, Aircraft plating, Finishing	Al, Ag, Cd, Cu, Cr, Hg, Ni
Alkali chlorine, Inorganic chemicals	Al, As, Cd, Cr, Hg, Fe, Pb, Sn, Zn
Organic chemicals, Petrochemicals	Al, As, Cd, Cr, Hg, Fe, Pb, Sn, Zn
Petroleum refining	Al, As, Cd, Cr, Cu, Fe, Pb, Ni, Zn
Flatglass, Cement, Asbestos products	Cr
Steam generation, Power plants	Cr, Zn

exchange, cementation, electrodeposition, solvent extraction and reverse osmosis are some of the successful methods employed in this field.

**Table 2. The limits of some of the toxic heavy metal ions in the effluent for supporting aquatic life**

<i>Toxic metals</i>	<i>Soluble ions not to exceed given ppm concentration</i>
Hexavalent chromium	0.05
Iron	0.3
Nickel	0.3
Copper	1.0
Zinc	5.0
Cadmium	0.01
Lead	0.1
Total mercury	0.005
Arsenic	0.05

However, most of the methods employed tend to be either uneconomical or incapable of consistently meeting the strict water quality standards currently being imposed by the public health authorities in many countries. Recently, some workers have been investigating the use of some unconventional methods and materials for scavenging heavy metal ions from industrial wastewaters. Natural polymeric materials such as wool, cotton, tree barks, and insoluble starch xanthates have been claimed to be very efficient in binding heavy metal ions. Other agricultural byproducts such as peanut skin, walnut expeller meal, bagasse, paddy husk, paddy straw, and flour waste have also been found to effectively bind some heavy metal ions from solution. Recent work done in Visvesvaraya Regional College of Engineering has shown that red

onion skin is highly effective in scavenging the heavy metal ions in solution. The dried onion skins are powdered and treated with formaldehyde in presence of dilute sulphuric acid. The product is then filtered, washed with water and dried.

By using columns of treated red onion skin, it is possible to reduce concentration of heavy metal ions such as  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Zn}^{2+}$  and  $\text{Cd}^{2+}$  to less than 0.01 ppm (which is within the acceptable safety limits) under steady state conditions. Further, it has been found that 1 gram of treated onion skin can hold 51.6 mg of copper or 125 mg of lead or 42 mg of zinc. Similarly, appreciable quantities of other heavy metal ions can also be held by the treated onion skin depending upon the experimental conditions. The metal ions so absorbed can be recovered by treating with dilute acid. After washing with water, the material can be repeatedly reused.

Thus, treated onion skin offers another cheap and widely available waste material which has potential application in effectively scavenging toxic heavy metal ions from industrial wastewaters.

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## Distillery waste

**A**LCOHOL industry in India is creating a serious water pollution problem. The undiluted waste, as it emerges from the distillery, is of deep red colour, possesses an extremely high biochemical oxygen demand (26,000-65,000 mg/l), chemical oxygen demand (55,000 - 1,15,000 mg/l),

total solids (90,000-1,10,000 mg/l) and a strong acidic pH 3.4-4.3). The waste also carries sulphur compounds which on stagnation decompose into  $H_2S$ , giving an offensive odour and imparting black colour to the waste. At 105 distilleries in India, about 3,178 million lit. of alcohol is manufactured and 6765 million lit. of spent wash is produced as waste per annum. The spent wash is discharged into streams as a waste causing severe water pollution problem. How then can such a huge amount of spent wash be utilized beneficially? Considerable work has been done to utilize valuable products from it.

### Methane gas

It has been observed that 10-12 days anaerobic digestion of spent wash results in the production of about 3,39,840 c.c. to 3,96,480 c.c. of gas for each 0.4536 kg of BOD load. The gas produced during digestion contains  $CH_4$  50%-70%,  $CO_2$  20%-25%,  $N_2$  2%-7%,  $H_2$  1%-5% and  $O_2$  0.1%. According to this, a distillery producing 4,54,000 lit. of waste, discharging about 18,144 kg of BOD/day (assuming average BOD of the waste to be about 40,000 mg/l) from which about  $1,35,936 \times 10^4$  c.c. methane gas can be recovered. In terms of fuel value 4.89 Cal/c.c. of methane gas corresponds to about 14-15 metric tonnes of coal/day. This gas can be used as fuel in boilers.

### Ammonia and urea

Methane gas instead of burning in boilers can be utilized for the manufacture of ammonia and urea. Ammonia can be obtained by catalytic synthesis of hydrogen and nitrogen. The source of hydrogen is methane gas and nitrogen can be obtained from air by liquefaction. The  $CO_2$  produced during alcohol formation and anaerobic digestion can be utilized for manufacture of urea. For 1 ton of liquefied ammonia, methane

Table 1. Chemical composition of spent wash

Products	Spent wash ash%	Composition of water solution Ash %	Water solution extracted from Ash%
Water soluble salt	7.0	47.70	100.00
Potassium oxide ( $K_2O$ )	27.12	24.21	51.27
Phosphates ( $P_2O_5$ )	3.25	—	—
Sulphates ( $SO_4$ )	12.16	12.16	25.49
Chlorides (Cl)	12.63	12.63	26.48
Calcium oxide ( $CaO$ )	11.86	1.10	2.33
Carbonates ( $CO_3$ )	0.46	0.46	0.96
Ferric oxide ( $Fe_2O_3$ ) and Alum oxide ( $Al_2O_3$ )	2.71	—	—

required will be  $6,79,680 \times 10^3$  c.c. Methane gas which can be manufactured from the waste of all distilleries of our country is enough to produce 2,46,466.36 metric tonnes of ammonia and 4,28,281.59 metric tonnes of urea per year.

### Methane derivatives

From methane gas valuable methane derivatives can also be manufactured. From a distillery producing 22,700 lit. of alcohol/day,  $1,35,936 \times 10^4$  c.c. of methane gas may be produced from which 58.5 % of methyl chloride ( $CH_3Cl$ ), 29.3 % methyl dichloride ( $CH_2Cl_2$ ), 9.7 % chloroform ( $CHCl_3$ ) and 2.5 % carbon tetrachloride can be obtained. These products can be separated by fractional distillation. By changing methane and chlorine ratio and the catalyst, any of the products can be obtained.

### Potassium salts

Potash can also be recovered from the spent wash. The spent wash has the chemical composition given in Table 1. (D.L.N. Rao and A. Gani, 1968, Nizam Sugar Factory, Shakkarnagar)

The molecular proportions of sulphates, chlorides and carbonates of potassium have been estimated against  $K_2O$  and percentage of the

salts calculated  $K_2O$  as  $K_2SO_4$  is 42.81%,  $K_2O$  as  $KCl$ , 54.23%,  $K_2O$  as  $K_2CO_3$  2.96%. The quantity of the respective salts that can be obtained per day from the water-soluble portion of the ash from a distillery producing 4,35,840 lit. of spent wash/day comes to  $K_2SO_4$  2,875.82 kg;  $KCl$ , 3,107.16 kg and  $K_2CO_3$  113.4 kg.

### Manure

If the data, given in the table, of chemical analyses are scrutinized, they reveal that spent wash is equally, if not more, valuable than alcohol, as it contains high amount of plant nutrients. A distillery producing 4,35,840 lit. of spent wash/day contains 456.184 metric tons of total solids/day which may yield 6,350.4 kg of nitrogen, 1,088.64 kg of  $P_2O_5$  and 1,360.8 kg of  $K_2O$ . The manure from spent wash can be obtained after neutralizing and concentrating it to 50 Brix (a unit, showing weight of a solute per volume of solution at a given temperature) that can easily be transported to a place where needed. Taking NPK requirement as 90.72 : 36.28 : 45.36 kg per acre for cane cultivation, the day's production of concentrated slopes in terms of full potassium value will cover about 30 hectares (3,628.8 kg potassium/day production) and nitrogen and phosphorus per acre would be about 7.93 kg and 13.60 kg respectively.

## Cultivation of yeast

The spent wash carries about 1.24%-3.65% of sugar and most of the biochemical oxygen demand is due to the presence of this sugar. Spent wash, as such, can be utilized for the cultivation of adapted yeast cells from wild yeast. The developing yeast cell consumes this sugar and brings down the BOD of the waste at the same time. There is nearly 4-5 fold increase in size of adapted yeast cell. This yeast is rich in proteins and vitamins and can be supplied as cattle feed. It has been pointed out that it is possible to adapt the yeast (*Saccharomyces cerevisiae*) in 100% spent wash without any nutrient addition. The growth of the adapted yeast was found to be 0.224 mg/mg of total sugar as compared to 0.116 mg/mg of total sugar for the wild yeast.

From the foregoing, it is obvious that distillery waste is a valuable product if it is properly handled and utilized. No doubt, that new plant

installation to obtain these products can cost equal or more than the cost of setting up the industry itself, and the industrialist may not support this programme but it is also their moral duty not to degrade the environment. In western countries tax incentives in different forms are given to the owners manufacturing such commodities, the same practice should be adopted in India as well. The government can also give subsidies to such producers utilizing the waste beneficially. In the interest of saving human life from the drastic consequences of pollution, the government can also install such industries for the utilization of the waste in the public sector. If such steps are taken, it will be a very useful and positive approach to the solution of the problem.

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dispersions of solids or liquids in gaseous medium.

Particulate clouds are widespread in nature and are met in many phases of modern civilization. Release of particulate matter into the atmosphere is one of the most acute environmental problems of today. Pollution by industrial and domestic smoke is widespread in industrial and urban districts.

There are two broad types of harmful effects arising from the inhalation of particulate clouds. The first is systemic and the other localized in the respiratory system. Suspensions such as lead dusts or certain pesticides which act as systemic poisons or cause loss of function are less size-dependent. The other type of effect is caused by the inhalation of dust and gives rise to a group of diseases known as the pneumoconioses, which comprise by far the largest number of cases of respiratory illness directly attributable in industrial particulates. There is also a smaller group of ailments called pneumonitis, a form of pneumonia caused by metals such as manganese, vanadium, cadmium and beryllium.

Various terms have been used to signify diseases due to specific dusts: silicosis due to dust containing free silica, asbestosis caused by breathing asbestos dust, byssionosis produced by the dust formed in the preparatory processes in cotton spinning mills, bagassosis from the grinding of bagasse (spent sugarcane) and siderosis occurring amongst welders and haematite miners.

Epidemiological investigations of respiratory diseases such as pulmonary tuberculosis, influenza and the common cold, have established beyond doubt that the disease spreads by airborne microorganisms, and methods of air hygiene such as disinfection by ultraviolet light and by chemical agents have been applied increasingly to their control.

Blankets and bedding can become highly infective, and air sampling in hospital wards has shown that

## World of particulate clouds

**P**ARTICULATE clouds are fine aerial suspensions of particles, e.g., dust, smoke, fog, mist, haze, etc. Dust is solid particles dispersed in a gaseous medium as a result of the mechanical disintegration of matter. Smokes cover a wide variety of gaseous disperse systems comprising fine particles which settle slowly under gravity. When a smoke is formed simultaneously with the production of a gas or vapour, it is called fume, e.g., in smelting, metallic oxide smokes are generated simultaneously with sulphur dioxide. Mists consist of droplets usually formed by the condensation of vapour, but they may also be produced by the atomization of a liquid. When the suspended drop-

let concentration becomes sufficient to reduce visual range markedly, the mist may be called a fog, but the line of demarcation is not well defined.

In the atmosphere, droplets and particles of atmospheric pollution and dust may be present together giving rise to haze, but this is merely a combination of three systems and not a different kind of suspension. Similarly, the term 'smog' is generally used to denote an aerial system formed when fog occurs in the presence of atmospheric pollution from domestic and industrial chimneys, but the term is also applied to other noxious suspensions in the atmosphere. The term aerosol is commonly applied to colloidal



large numbers of bacteria are dispersed from blankets, etc., during making the beds. The effect may be equally serious in homes when a member of a family is infected with respiratory disease.

The emission of particulates in chemical industry poses a health hazard. Examples are cement dust, sulphuric acid mists, iron and zinc oxide smokes, and various fluorine compounds.

The atmosphere contains suspended particles of many kinds; smoke from industrial areas or from burning forests, minute living organisms, dust from the earth and from outer space, salt particles from the sea and water in the form of droplets, ice crystals or snowflakes. The system as a whole (air plus particles) may be regarded as a complex colloidal system, or more specifically an aerosol, in which vast numbers of finely divided liquid and solid particles, constitute the disperse phase.

Water occurs as a constituent of both the disperse phase and the dispersion medium, depending upon the conditions of temperature and pressure. The familiar natural phenomena of cloud, fog, mist, and haze are essentially manifestations of disperse systems in which a liquid or solid is dispersed in a gaseous medium in the atmosphere.

Chemicals for the control of insects, fungi and weeds are frequently sprayed in the form of minute solid particles or liquid droplets. Depending upon the particular purpose, the degree of dispersion employed varies from relatively coarse sprays to true aerosols.

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H - ala-gly-cys-lys-asn-phe-phe-trp-lys-thr-phe-thr-ser-cys-OH.

Using most recent techniques like radioimmunoassay, immunocytochemistry, etc., it was discovered that somatostatin-like activity (SLA) is not confined to the hypothalamic region but has a widespread phylogenetic as well as anatomic distribution. In the neuronal elements and axonal fibres of central nervous system including spinal cord, in discrete secretory cells of epithelial appearance in stomach, pancreas, gastrointestinal system, etc., of a wide range of animals (hagfishes, torpedofish, pigeon, rat, hamster, dog, baboon, rhesus monkey, sheep, pig and man), SLA has been found to be present.

Soon it was discovered that somatostatin is not only a hypothalamic growth hormone release-inhibiting factor, but it also has the capacity to inhibit secretion of thyrotropin, glucagon, insulin, gastrin and secretin hormones and secretion of pepsin, HCl and the secretion of the pancreas.

#### Somatostatin and diabetes mellitus

Diabetes mellitus, one of the most intensively studied human disease, shows complex pathological symptoms like hyperglycemia (presence of higher blood glucose concentration than the normal) often accompanied with glucosuria, polyuria, ketonemia, ketosuria and acidosis. Earlier it was believed that diabetic hyperglycemia is mainly caused due to insulin deficiency and insulin is the only treatment. But now it has been found that not only insulin deficiency is the cause of diabetic hyperglycemia and other related symptoms, glucagon also plays an important part. In severe hyperglycemic conditions, symptoms of ketoacidosis etc., are, due to excess glucagon in the blood. In normal condition glucose-hemostasis of the body is regulated by glucagon and insulin. When insulin secretion decreases glucagon level

## Somatostatin and its use in medicine

AT The Salk Institute, La Jolla, California, Roger C. L. Guillemin's school was busy in search of various hypothalamic releasing factors responsible for secretion of various pituitary hormones (Fig. 1). Two of his colleagues, Wyle Vale and Paul Brazeau, discovered a protein in the ovine hypothalamus (in 1972), which unlike other releasing factors was found to inhibit secretion of growth hormone from the pituitary (Fig. 2). Guillemin's school isolated and characterised the protein and named it "Somatostatin"; *Somato* from somatotropin, a pituitary growth hormone and *stat* (in) from the Latin "to halt,

to arrest". Though the discovery of this molecule was rather accidental, soon it was found to be of immense therapeutic as well as theoretical importance. For the discovery of releasing factors and somatostatin, Guillemin was awarded Nobel Prize in 1977 for Physiology and Medicine along with Rosalyn S. Yalow and Andrew V. Schally, both of U.S.A.

The somatostatin isolated from the ovine hypothalamus is a small 'O' shaped tetradecapeptide (a peptide containing 14 amino acid residues) with a disulfide bridge linking cystine at position 3 and cystine at the position 14. The molecule has the following primary sequence:

## Somatostatin and gastrointestinal system

Somatostatin enhances levels of some gastrointestinal hormones by direct action on the secretory elements of these peptides. Somatostatin administration has been shown to inhibit secretion of gastrin (normally gastrin secretion is induced by meals). Somatostatin in large doses also inhibits exocrine pancreas secretions, gastric secretions, and secretin. Recently, Guillemin has shown that somatostatin alone can inhibit the secretion of acetylcholine from the (electrically stimulated) myenteric plexus of the guinea pig's small intestine. (Myenteric plexus is a nerve network lying in the submucosa of the digestive tube. It is well-established that when electrically stimulated, nerve endings release neurotransmitters like acetylcholine. Acetylcholine is believed to be responsible for the gut contraction.) This may perhaps be the reason for inhibitory effects of somatostatin on gut contraction.

## Somatostatin and growth hormone

Human subjects having growth hormone producing pituitary tumors suffer with increased growth hormone secretion. In all these cases increased growth hormone can effectively be suppressed by somatostatin adminis-

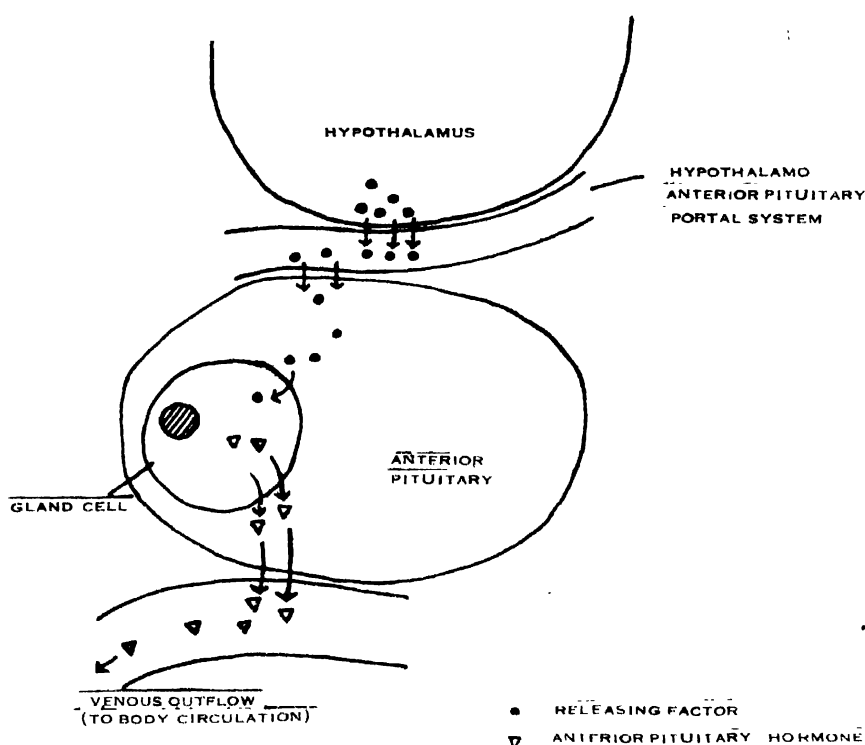


Fig. 1. Secretion of anterior pituitary hormones in response to hypothalamic releasing factors

increases which compels some processes to form more glucose, resulting in increased blood glucose level. When insulin level increases, glucagon level decreases and glucose level falls. Somatostatin administration causes simultaneous decrease in plasma insulin, glucagon and glucose level (Table 1). In a normal case decrease in insulin level may result in increased glucose level, but when somatostatin is administered, glucagon level also decreases, maintaining the decreased glucose level. This observation for the first time, gave a clear cut evidence that glucagon has a hand in maintaining glucose homeostasis in the body.

In juvenile diabetes, where post-prandial (after feeding) hyperglycemia could not be inhibited by only insulin administration, somatostatin along with insulin made it normal. Upon discontinuing somatostatin, a rebound in both plasma glucagon level and post-prandial hyperglyce-

mia were observed on the same insulin dose. This shows that somatostatin can decrease excess secretion of glucagon (which cannot effectively be eliminated even by aggressive treatment with insulin). Another remarkable observation is that somatostatin alone, i.e., in the absence of insulin, prevents ketoacidosis in juvenile diabetes.

It has already been reported that somatostatin suppresses glucagon insulin secretion. There occur some pancreatic tumors which secrete either glucagon or insulin in excess. So somatostatin can be therapeutically administered for the treatment of individuals with such tumors. In insulinoma patients it has been observed that insulin secretion is inhibited by somatostatin. Infusion of somatostatin in such patients should be performed cautiously since, despite lowering of basal insulin levels, plasma glucose level may fall precipitously.

Table 1

Conditions	Concentrations of	
	Insulin	Glucagon
1. Glucose administration	↑	↓
2. Fasting Exercise Pancreatectomy	↓	↑
3. Somatostatin Administration	↓	↓

↑ = Increase      ↓ = Decrease

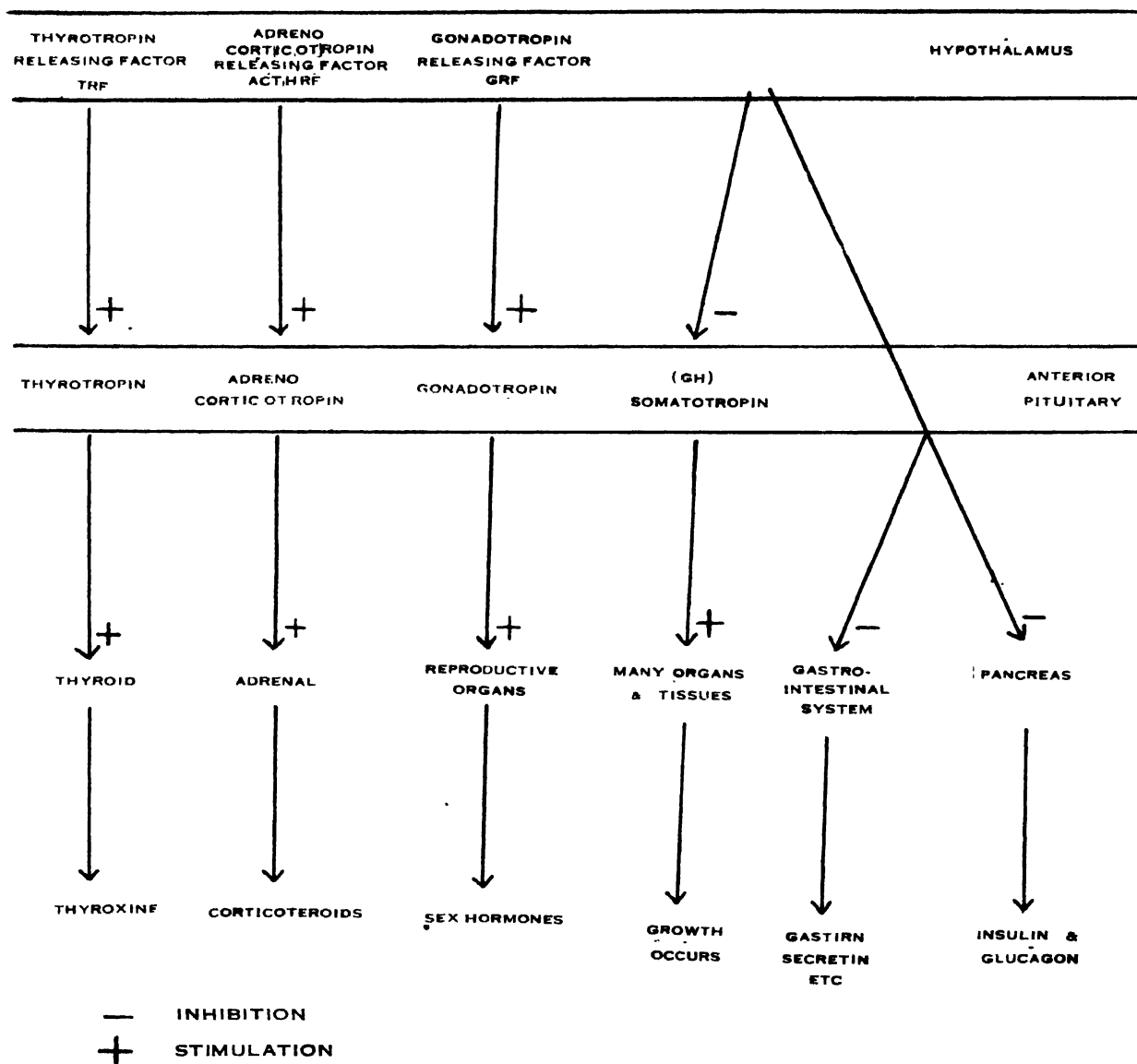


Fig. 2

tration. So, in pathological states associated with elevated basal growth hormone-levels (e.g., acromegaly, protein-caloric malnutrition and diabetes), somatostatin can be used successfully for suppression of growth hormone secretion.

TRF (thyrotropin releasing factor) is released by hypothalamus, in response to which thyrotropin is secreted from the pituitary. It has been observed that thyrotropin responses to TRF are inhibited by somatostatin but interestingly basal

levels are not affected.

Somatostatin does not affect the pituitary secretion of luteinizing hormone, follicle stimulating hormone and adrenocorticotropin. Amazingly, in patients with pituitary tumors (adenomas) and acromegaly unusual

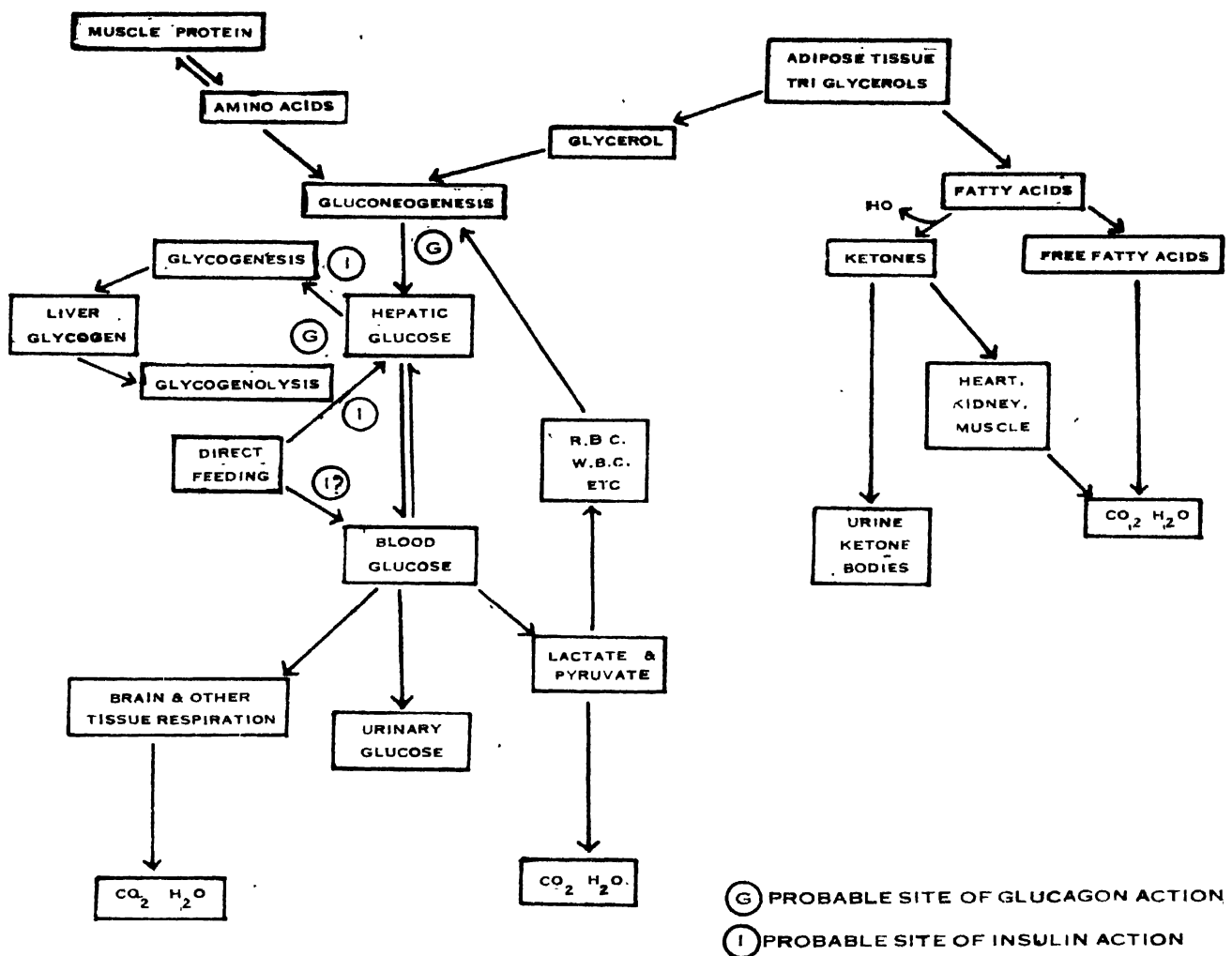


Fig. 3. Glucose metabolism in body

response to somatostatin is observed. It has been reported to lower fasting prolactin levels in patients with acromegaly and ACTH levels in patients with Nelson's syndrome.

Although some adverse haematological effects like diminution in platelet aggregation have been reported in baboons and rabbits receiving large doses of somatostatin, no serious toxicity is observed in man. But these reports cannot be taken as conclusive as they lack adequate control studies and even in many cases somatostatin preparations may not be pure.

#### Therapeutic implications

Apart from the inhibitory role of somatostatin on various hormone secretions, it is hoped that somatostatin can be used as a successful curative agent in certain clinical conditions such as acromegaly, pancreatic islet cell tumors, diabetes mellitus, etc. In case of endocrine tumors, though it is not expected to diminish tumor growth, it may inhibit excessive hormone secretion; thus in such conditions somatostatin can be used as a temporizing agent. Scientists believe that in diabetic retinopathy and diabetic ketoacido-

sis somatostatin may be used successfully to prevent or retard the severity.

By using gene manipulation technique, bacteria can be programmed to produce somatostatin in pharmaceutical quantities. A DNA sequence constituting a gene for somatostatin has already been synthesised and is ready for cloning.

As somatostatin has inhibitory effects on various hormones, its administration will definitely create many unwanted complications. For example, if a diabetic patient is treated with somatostatin to inhibit excess glucagon secretion, it may

inhibit insulin secretion also. If a somatostatin analogue having inhibitory effect on glucagon only could be discovered or synthesised, this side-effect may be controlled. Presently, many scientists are busy in finding out various somatostatin analogues which could be used effectively in various clinical conditions. One such analogue, [des-Asn<sup>8</sup>]-somatostatin, may inhibit secretions of growth hormone, insulin and glucagon, respectively. Another analogue is

[D-Trip<sup>6</sup>, D-Cys<sup>14</sup>]-somatostatin. The natural somatostatin has a very short half-life (about 2 minutes) which poses a great problem during administration. Scientists are trying to find an analogue with longer half-life but with same or more potency as that of the natural molecule.

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## Rhizosphere

**T**HE immediate root system of plants is associated with an inanimate environment composed of organic and inorganic substances as well as several metabolically active microflora. The microorganisms constituting this microflora live in an unstable equilibrium—a state in which at any one time each individual is in balance with its neighbours but in which changes in environmental conditions lead to changes in the equilibrium. The term 'rhizosphere' was first introduced by German scientist R. H. Hiltner in 1904. It refers to that portion of soil which is subject to influence of plant root systems. The rhizosphere is not a uniform, well-defined zone; instead, it has a microbial gradient. The influence of the root system is maximum at the immediate root surface or 'rhizoplane' and decreases with increasing distance, both vertically and horizontally, from rhizoplane.

### Effect of plants on rhizosphere microflora

Rhizosphere is a highly favourable habitat for proliferation and metabolism of numerous microbial

types including bacteria, fungi, actinomycetes, free-living nematodes, algae, and protozoa.

The living root cap cells provide nutrients near the tip and elongation zone. Root hair and cortical cells die as plants age. Eventually the whole root dies thereby making all the tissue available for feeding microbes. A miscellany of compounds such as vitamins, amino acids, peptides, organic acids enzymes, etc., are found in root exudates. Besides there are trace amounts of various substances with specific biological activity such as nematode cyst-hatching factor and fungal zoospore attractants. The amount and quality of nutrients determine the size of the population and the nature of the rhizosphere microflora.

Rhizosphere contains more microorganisms than the soil free from the influence of plant roots. The ratio of the number of microorganisms present per unit of rhizosphere to that present per unit of non-rhizosphere soil is expressed as R/S ratio. This R/S ratio is highest at the immediate root surface or 'rhizoplane', falling off sharply with increasing distance. For bacteria, the R/S

ratio may reach as high as 100 or even more, especially in the legumes. Actinomycetes, fungi, algae, and protozoa show more modest increase. This quantitative effect reaches its maximum at the age of greatest vegetative growth. The microbial population declines with the death of the plant, and generally with the exception of forms like cellulose decomposers, reverts back gradually to the level of the surrounding non-rhizosphere soil.

The stimulated bacteria are gram-negative rods and pleomorphic forms capable of fermenting carbohydrates. They decompose cellulose and cause denitrification and ammonification.

Environmental factors like intense light, high temperatures, temporary plant wilting, root damage, etc., favour exudation. Besides, foliar application of certain substances, such as urea, causes marked increase in the root exudation of glucose, fructose, glutamine, and alanine, whereas organic acids are decreased.

### Effect of rhizosphere microflora on plants

Rhizosphere microflora exert profound influence on plants. Plant-rhizosphere microflora interaction is a widespread phenomenon and includes both promotion and demotion. Availability of nitrogen is affected adversely. Nitrification does occur but at the same time nitrogen gets immobilised by the activity of microorganisms.

Immobilization of zinc (Zn) by microorganisms causes the deficiency disease "little leaf" of fruit trees. "Grey speck" of oats is caused by bacterial oxidation of manganese (Mn). Rhizosphere microflora have been reported to be capable of affecting the molybdenum (Mo) content of plants. Their activity leads to decreased uptake of elements like sulphur (S), calcium (Ca), and rubidium (Ru).

Some rhizosphere microflora produce indole acetic acid (IAA) and gibberellin-like substances. Extracts of several rhizosphere bacteria, including *Azotobacter chroococcum* and *Rhizobium japonicum* possess a cytokinin-type of activity.

#### Benefits

Several of them produce antibiotics, e.g., an antibiotic isolated from *Azotobacter chroococcum* was found to suppress *Candida albicans*, *Alternaria* sp. and *Monilia* sp. Such antibiotics protect plants from pathogens.

Rhizosphere microflora also provide assimilable food to plants through organic decomposition. Increased concentration of carbon dioxide (CO<sub>2</sub>) in rhizosphere resulting from microbial respiration aids greater solubilization of soil minerals.

#### Rhizosphere microflora and plant pathology

Non-pathogenic microorganisms comprise the bulk of the rhizosphere microflora. The observation that soil borne plant pathogens, with few exceptions, are more destructive to their hosts in sterile soil than in normal soil indicates a role for the microbial interactions at the rhizosphere—competitive, antagonistic and, in some cases, beneficial when it protects plants from pathogens.

Rhizosphere microorganisms have been reported to be capable of suppressing plant diseases through their antagonistic effect on root-infecting pathogens, e.g., *Trichoderma viride* protects pine roots from *Phomes annosus*. The immunity of monocots *Phymatotrichum omnivorum*, the agent of 'texus root rot' of cotton and other plants has been attributed to the activity of rhizosphere microflora.

#### Prospects

Rhizosphere is a microbial buffer

zone which protects the plant from pathogen. Several mechanisms have been suggested to explain the buffer action—antibiotic production, formation of physical barrier by rhizosphere microflora, ousting of the pathogen through deprivation of nutrients, etc. Future developments could profitably explore the possibilities of using inocula of mixed cultures of organisms all acting on a disease in different ways, such as inhibiting

pathogen proliferation competing for nutrients, providing growth regulators, etc., used together with the techniques for modifying rhizosphere environment. This may enable us to control plant diseases which appeared invincible hitherto.

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## Repellents, attractants and chemosterilants for insect pest control

NUMEROUS devices have been employed in the past by man to control insect pests. Although a variety of insecticides are in common use, none has succeeded in the complete eradication of these pests. With increasing use of insecticides, insects have developed resistance to them. Further, insecticides cause environmental pollution, which makes life more miserable and increases the danger of poisoning of mankind as well as of the useful animals. These dangers of increasing use of insecticides have stimulated research for control methods without the use of toxic chemicals.

Insects have managed to persist despite hostile surroundings because of their extraordinary adaptability. For example, many insects depend on their highly specialised olfactory senses and have specialised olfactory organs. The front part of the insect body has two antennae, which act as the olfactory sense organs. Under the cuticle of some insects there are several receptor cells which are highly sensitive and

specific to odours. Many species recognise their mates, food and egg-laying sites by these senses. Molecules of chemical compounds, often in minutest amounts, diffused in the air provide the insect with information about the odour source. Within a few centimeters of an odour source, an insect is able to detect it and orient its body accordingly.

Among the safest and the most useful methods developed by entomologists, are insect repellents, attractants and chemosterilants, which make use of the insect's olfactory capabilities.

#### Repellents

Repellents are materials which when applied to a particular spot causes the insect to move away from that place. Several safe and effective repellents are now known, like dimethyl phthalate (DMP) (C<sub>10</sub>H<sub>10</sub>O<sub>4</sub>), dimethyl carbate, indalone (Butopyronoxyl) (2, 2-dimethyl 6-carbobutoxy-2, 3-dihydro-4-pyrone), Rutger's 6-12 (Ethohexadiol) (2, ethyl-1, 3-hexanediol), diethyl

tolumide (DEET) (N, N-diethyl m-tolumide), etc. Many essential oils like lemongrass oil and oil of citronella have a repellent effect on certain insects such as houseflies, mosquitoes and cockroaches. Most essential oils, however, have a limited repellency, especially to mosquitoes and the effect is usually short-lived.

Repellents when applied on the body act as barriers for the insects and prevent them from biting the coated surface. Some repellents are volatile so that the insect is turned away from the skin without even touching it.

A repellent should be cosmetically pleasing and non-irritant and easy to apply with hands. It should preferably be relatively insoluble in water, so that it can be applied to dry, as well as wet, perspiring skin.

No good insect repellent is known for use on agricultural pests. A volatile repellent does not last long enough and frequent spraying of a repellent over a long growing season is not economical.

## Attractants

An attractant is a substance which causes an insect to move towards it. Insect attractants are abundant in nature. Insects respond to attractants present in their food and also to plants or animals that serve as their place of living and reproduction. Use of food attractants, such as soyabean oil, for the eradication of insects is one of the many methods employed to control insect pests. The attractants are mixed with an insecticide so that insects attracted towards it are killed.

Besides the food attractants, there are sex attractants also. Many of the male insects respond to sex attractants (called pheromones) produced by female insects. Scientists have isolated sex pheromones from insects and synthesized chemicals related to the attractant that has

proved highly successful in controlling insect pests.

## Chemosterilants

One of the outstanding characteristics of insects is their ability to increase rapidly in number even under relatively unfavourable circumstances. Among the various new approaches to pest control now being used, artificial sterilization of insects offers most challenging opportunities. One way to induce sterility in insects is by the use of chemicals known as chemosterilants. Insects can also be sterilized by using radiation (usually X-rays), but the technique is too expensive.

Two methods of chemosterilization have been employed for suppressing insect population. One system consists of the mass production, sterilization and release of sterile organisms so that they interfere with reproduction in the natural fertile population. The other system involves the sterilization of the required proportion of the natural population by appropriate means. The sterilized individuals cannot reproduce and at the same time, they further control reproduction by competing with the remaining fertile individuals in the natural population. The actual techniques for practical application of the two methods differ from each other.

In the sterile male technique

hundreds of millions of the insects are reared for sterilization and are subsequently released into the environment. The reared sterile insects then compete for mates with the normal insects in the population. The mating between these sterile insects and normal wild insects results in infertile egg. By releasing more number of sterile insects into the environment and by continued release for several generations, the decreasing number of sterile individuals in the natural population finds a lesser number of fertile mates and gradually the chances for successful fertile matings become nil.

The sterile-male release technique have been applied successfully against the screw-worm fly and several tropical fruitfly species in the USA.

The release method is costlier than application of insecticides when the natural populations are high, but may be economical when the natural populations are low.

The use of attractants, repellents and chemosterilants can thus play an important role in achieving the eradication of the dangerous pests effectively, economically and with complete safety to man and his environment.

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## Why should there be fat in milk?

THE most valued component of milk is fat. Cows yielding milk with high fat percentage are expensive to buy. The fat of milk also forms the basis of most sweetmeat industry. The lipid content of

the milk is also the most variable of its major components. It ranges from zero in the milk of rhinoceros and 2 percent in that of the horse to as much as 50 per cent in the milk of aquatic mammals. Fat

in human and cow milk is about 4 percent, rodent milk 12 percent and milk of polar bear contains 33 percent. Fat is a major source of energy in the diet of young mammals and provides about 70 percent of calories in rat milk and considerably more in the milk of the polar bear and seal where fat content is extremely high and lactose low. This is understandable, because the seal and polar bear which live in extreme cold environment need a highly concentrated source of energy which at the same time serves as an insulator to the loss of body heat. This function is well served by the fat in milk. The whale, living in subzero temperature also needs a high energy source in the milk for the survival of its young. Whale's milk contains the highest milk fat percentage (well above 50 percent). One gram of fat provides 9 kilocalories of energy while the same amount of protein or carbohydrate provides less than half as much (approx. 4 kilocalories). The mammary tissue is one of the most active tissues in the body with regard to lipid synthesis. In the high lactating cow, it is not uncommon for the animal to synthesise and secrete 1.5 kg of milk fat per day.

The major lipid component of milk of all species is triglycerides, accounting for more than 95 percent of the total lipids. It is present in the form of fat droplets which range from 1  $\mu\text{m}$  to 7  $\mu\text{m}$  in diameter. Fatty acids in milk are mostly of long chains with 14 to 18 carbon atoms per molecule and are either saturated or unsaturated. Milk triglycerides also contain medium chain ( $\text{C}_8$  to  $\text{C}_{12}$ ) and sometimes short chain ( $\text{C}_4$  to  $\text{C}_6$ ) saturated fatty acids. The milk of human female contains 91 per cent long chain and 9 per cent medium chain fatty acids. Studies on humans suggest that most  $\text{C}_{16}$  and  $\text{C}_{18}$  fatty acids in milk are derived from diet. However, in ruminants, the chain elongation from lower fatty acids

to higher fatty acids takes place in the mammary gland cells, although milk in these species contain predominantly lower fatty acids like butyric and caproic acids. Lipids in milk are sometimes called its butterfat content; they exist as minute droplets or globules that under proper conditions will rise to form a layer of cream, say, after boiling and letting the milk cool. Agitation in the form of churning causes the globules to aggregate into granules that can be gathered and worked into butter. Butter is about 80% fat and the part that is not fat, is mainly water. If butter is melted, clarified

and dried, it yields a product that is almost 100 percent fat and is known as butter oil. It is used commercially in making candy and baked goods.

But milk fat too has its limitation. Excessive amount of fat in diet leads to the fatal human disease, atherosclerosis. This disease is due to the deposition of cholesterol in arteries, thereby blocking their passage and causing heart attack.

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## The tree that grows chocolates

A native of the central and north South America, the chocolate tree is cultivated in many countries of the tropics in both the hemispheres. In India, it is cultivated in some parts of South India and Orissa. Botanically, the plant is named *Theobroma cacao* and belongs to the family *Sterculiaceae*.

The plant is a small evergreen tree, sometimes reaching upto 12 m in height with a dense rounded crown. From the trunk itself, small rounded "Cushions" protrude and on these small, pink flowers appear. Cocoa is cauliflorous, i.e., the flowers and fruits are borne on the older leafless parts of the trunk and lateral branches (Fig. 1). The fruit swells to mature size and shape resembling a reddish orange to dark purple football, 25cm-30cm long and as much as 12 cm in diameter (Fig. 2). During a year any good chocolate tree generally bears 60 to 70 fruits and every month a few of them hang grotesquely on the trunk or large branches.

Before the arrival of the Europe-

ans in tropical America, the Aztecs domesticated the chocolate tree. They regarded its fruits more valuable than gold, because chocolate could be drunk or eaten. In pre-Columbian days, they were a medium of exchange throughout the Aztec and Inca Empires and called in the Nahuatl language as *Chocolatl*.

The seeds and pulp are removed from the fruit and allowed to ferment. This, along with the increase in temperature, cures the seeds and improves their flavour. After the fermentation is over, seeds are washed and dried. They are now known as "Cocoa beans" and ready for storage or shipment or use. Christopher Columbus brought "Cocoa beans" to Spain in 1502 after his fourth voyage to the New World. The taste of the bitter beverage made from ground roasted seeds, hot water and vanilla was improved by the addition of sugar. By about 1700, the English changed the recipe again by adding hot milk to the delicious drink. More than a century later, a Dutchman patented a machine for





Fig. 1. Pods of *Theobroma cacao* on the trunk (From "Living Plants of the World" by Lorus and Margery Milne)

"Ah! tea for the Gods" and gave it the Greek generic name *Theobroma*, which represents this expression.

Seeds are the principal source of cocoa or cocoa powder, highly prized as a nutritious beverage and the chocolate, used as food the world over. In bakery and confectionery the powder is commonly and extensively employed. Cocoa butter is used in the finest chocolates, cosmetics, ointments and soaps. It is also used in pharmaceutical preparations. Theobromine, an alkaloid obtained from the seeds has therapeutic properties similar to those of caffeine, and is used in cola drinks.

Chocolate trees are now cultivated in large orchards and pruned to a size that keeps their fruits within easy reach of the pickers. Much of the cocoa is still cultivated in Brazil, Venezuela, Trinidad, Ecuador and Panama, but the plant is now grown commercially in the Gold Coast of Africa, Nigeria, Sri Lanka and Indonesia. Little of it is used in the native areas but its demand for chocolate

pressing the ground roasted seeds, yielding cocoa powder and a valuable byproduct Cocoa butter, as a natural fat. If Cocoa butter and sugar are added to ground roasted cocoa beans, the product is the sweet eating chocolate. Today it is difficult to realize that this favourite among the world's confections was not available before 1850 and that Swiss milk chocolate had its beginning in 1876. When the Swedish botanist Linnaeus tasted the chocolate, he is said to have exclaimed

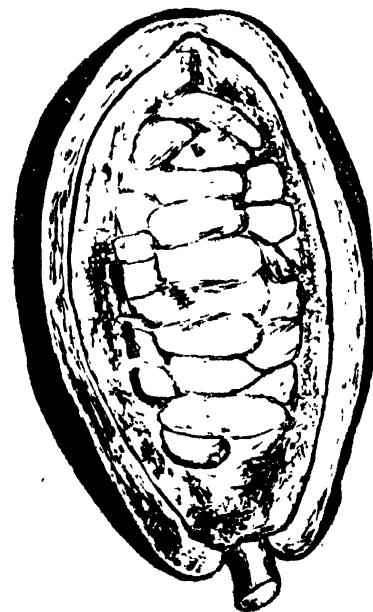
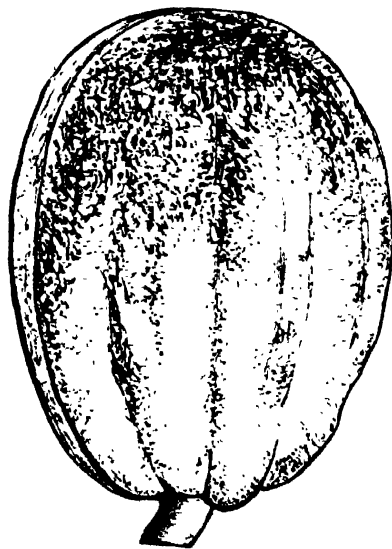


Fig. 2. Fruit and cocoa "beans" of *Theobroma cacao* (From "Botany - An Introductory Survey of the Plant Kingdom" by James D. Haynes)

candy and as flavouring agent in Europe and America makes production of cocoa beans important wherever the trees can grow well. U.S.A. is the largest importer followed by West Germany, U.S.S.R., etc.

In India, the chocolate tree was first introduced about 50 years ago from Sri Lanka. The oldest plantation of any importance was done at the Fruit Research Station, Kallar at the base of the Nilgiri Hills in Tamil Nadu. Some of the trees planted in the early thirties produced much of the material for planting in other places in South India. Scattered plantations are also found in pri-

vate compounds in various towns of Tamil Nadu, Karnataka and Kerala. Besides South India, in Orissa there are few plantations of the chocolate trees. Although demand for cocoa-based products progressively increasing in India the large-scale cultivation of the cocoa trees and the production of beans is yet in the early stages. Presently the demand for cocoa is met by imports of raw and roasted beans and unsweetened powder.

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## The giant kelps

**K**ELPS are unique in their size and usage. In most cases they grow into thick masses and form a marine kelp forest far different from the forest on land. They are tallest and biggest plants in the sea and hence designated as giant kelps.

Kelps are large brown sea weeds attached to rocky substratum in the sea. They belong to the class Phaeophyceae under algae. *Macrocystis pyrifera*, *Nereocystis luteana*, *Pelagophycus*, *Postelsia palmaeformis*, *Sargassum*, *Fucus* and *Laminaria* are some of the well-known kelps. They are economically important as sources of potash and algin, and usually form dense forests by their profuse growth at a depth of 10 m - 30 m. Their morphological characteristics are discussed below.

### Macrocystis

Greek—*Markros*=large; *kystis*=a bladder (Fig. 1A). It is attached to dry

rocky substratum under water. The stem of the plant is about 1 m in diameter and attains a length of 60 meters. It is strong, hard, and on it, arise a number of leaf-like appendages, each about 1 m in length bearing spinescent outgrowths at its margin. At times it spreads for many kilometers and forms dense mats along the sea surface, it shares with *Nereocystis* and forms thick subtidal forest. *Macrocystis* is considered to be the longest plant in the sea.

### Nereocystis

Greek—*Nereis*=daughter of the ancient sea god Nereus; *kystis*=a bladder (Fig. 1B). This is the second giant kelp showing certain unique characteristics. It grows on rocks in water (5.25 m depth) and shows a very strong stem about 30 cm in diameter and 12 m - 30 m in length. The tip of the stem develops into a unique nematocyst, bearing a number of elongated leaves ranging between 30-64 in number. Each nematocyst is

14 cm in diameter and 3 m long. *Nereocystis* is commonly called as the "bull kelp", "bladder kelp", "ribbon kelp" and "sea otter cabbage". It is a good source of potash.

Still another kelp, *Pelago phycus* (Greek—*Pelagos*=the sea; *Phykos*=a sea weed) spreads like an umbrella (Fig. 1C) when mature. It is similar to *Nereocystis* having a very strong stem and also a nematocyst at its apex. The stem is about 30 m long, and, from the tip of the nematocyst grows, on opposite sides, two branches, each branch bearing 4-6 leaves. The leaves are long (6 m) and are attached to the branches by means of short stalks. Also named as "elk kelp", "sea pumpkin", and "sea orange", it is a good source of potash.

The *Fucii* and *Sargassums* (Figs. 1E and 1F) are inexplicably troublesome to sailors by their vigorous growth and thick bed formation. Quite often such beds provide breeding and grazing areas for marine animals. Both are well provided with vesicles which help them to float in water. The famous 'Sargasso sea' in North Atlantic has been a trouble maker to sailors for a long time.

The *Laminaria*, unlike *Fucus*, *Sargassum* and other forms, is exceptionally called leaf kelp because of its expanded thallus. A single plant may attain a height of 8 m in length.

In *Postelsia* (Fig. 1D) there is a palm-like appearance as the specific name indicates, though it has no relationship with original palms. The hollow stems are erect and adapted to withstand any adverse conditions that may arise in its environment. It can bend horizontally when struck by heavy flow of water and assumes normal position when water recedes.

Kelps are economically important for the percentage of potash they yield. In Europe, cattle feed is manufactured from kelps. During the World War I (1917) it is estima-



Fig. 1

ted. that about 3500 tonnes of potash had been extracted from *Macrocystis* itself. *Sargassum*, *Fucus* and *Laminaria* are good sources of *algin*, a usual cell wall constituent in brown algae. *Laminaria* is being used in China for treating menstrual

difficulties in women.

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## Embryo transfer for livestock improvement

**I**N embryo transfer, ovaries of a female are stimulated by hormonal treatment. She is then mated with a male or inseminated artifici-

ally. The fertilized ova are subsequently recovered from the uterus and deposited into the uterus of recipient females. The recipient female acts as a foster mother for the development of the embryo. Recent studies have shown that unfertilized ovum can also be recovered from ovaries, fertilized *in vitro*, cultured through a series of divisions, and finally implanted in a synchronized foster mother for further foetal development.

The major contributions of embryo transplantation work to animal genetics and livestock improvement are: expansion of limited gene pools, proliferation of blood lines of genetically superior females, facilitation of transport of genetic potential to different areas, increase in population by twinning, decrease in generation interval in selection programmes, and contribution towards pre- and post-natal gene-environmental interaction studies.

Nowadays, in many countries cross-breeding programmes involve improvement of production potentiality of animals by using exotic breeds. But due to limited quarantine station facilities or other reasons of importation of breeding stock, the animal scientists are adopting embryo implantation programmes to expand the 'exotic' gene pools. Expansion of the limited gene pool of exotic beef cattle population by embryo implantation is presently quite common in Canada. The embryo transplantation techniques are now more or less standardized in pedigree livestock. Exportation of sheep and pig germ plasm by embryo transfer techniques was pioneered in Britain at Agricultural Research Council's Animal Genetics Laboratory at Babraham, U.K. As we know, it is easier to transport a blastocyst—the product of two pedigree parent animals—than to transport the animals themselves. The blastocysts, brought to the appropriate stage of development in the

laboratory, are temporarily implanted in the uteri of rabbits and then transported anywhere. On arrival at the destination, the "carrier" animals are hormonally conditioned and blastocyst is transferred to "foster" mother of the right breed.

Generally, the farm animals produce a limited number of offspring in their lifetime. But, today with the development of artificial insemination technique, the males with superior genetic make up are utilized to produce a good number of livestock. The recent advancements in the methodology of embryo transplantation offer the geneticists new opportunities for the proliferation of identified genetic superiority in females. It is now possible to produce a number of full-sib sisters of the same age from cows of superior genetic make up. The prospect of recovering a higher percentage of the thousands of primary oocytes lying in the ovaries of new born females is a challenge to the reproductive biologists. Embryo transfer offers a bright prospect in obtaining a large number of offspring by the recovery of mature ova from superovulated females. The exploitation and utilization of this unused genetic potential is yet to be adopted as a routine practice in livestock improvement programmes.

Milk and meat production potential may be increased by producing twins in all dairy cows through nonsurgical implantation of scientifically preserved embryos (S.R., February 1979). Besides, the frozen embryo banks may be useful in establishing genetic pedigree standards and to act as control for genetic change in selection experiments.

Long generation interval, i.e., the higher average age of the parents when their offspring are born is one of the constraints of farm animal improvement. Efforts to reduce this period by different breeding programmes are in progress with varying results. This aspect may be taken care of by adopting embryo transplanta-

tion in selection programmes by the use of females before reaching puberty.

Although much development has been made in embryo transplantation and animal improvement in many countries, very little attention in this direction is being given in India. Few leading veterinary institutes and colleges have recently started working on this problem. And once the techniques of embryo transplantation become standardized, the animal geneticists will

be able to utilize them to increase production efficiency through full utilization of the identified genetic potential of both males and females.

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## Why do some fishes discharge electric current

**F**ISHES live in a fantastic variety of habitat—from the dark oceanic abysses to the boundless surface of the open seas. They encounter vagaries of nature and some of them have fought for survival by evolving the most mysterious and inexplicable weapons like the electric organs.

Two hundred and fifty two species of fishes are capable of generating bioelectricity with the help of certain specialised tissues of their body to constitute the electric organ. The organs are capable of producing electric current which may give shock to animals and human beings when they come in contact with the fishes. In some cases, the shock is very powerful and can even kill a big animal. Among fishes which possess electric organ Torpedoes of the tropical and temperate seas, skates, snout fish (*Mormyrids*) of Africa, Electric eel (*Electrophorus*), Electric catfish (*Malapterures*) and star-gazers (*Uranoscopus*) are the important ones.

### Origin of electric organs

Electric organs are developed by

the modification of muscular tissue of the fish. In some fishes, they are developed from the embryonic striated muscle cells, while in others by the motor-end plate. In Torpedoes, some of the branchial muscles are transformed to form the electric organ by leaving their original function of moving the gill arch. In electric eel, skates and snout fishes, the electric organs take their origin from some of the lateral tail muscles, whereas in cat fishes it is the body muscles that form the organ. In star-gazer electric organ develops from eye muscles. Despite the basic similarity in the formation of the electric organ in various species, there are differences in the appearance, position in the body and mode of nerve supply. It appears that these organs have developed independently in a number of species in the long history of piscian evolution.

### Internal structure

Structurally each electric organ (Fig. 1) is composed of a number of regularly arranged flattened or disc like multinucleate cells, called

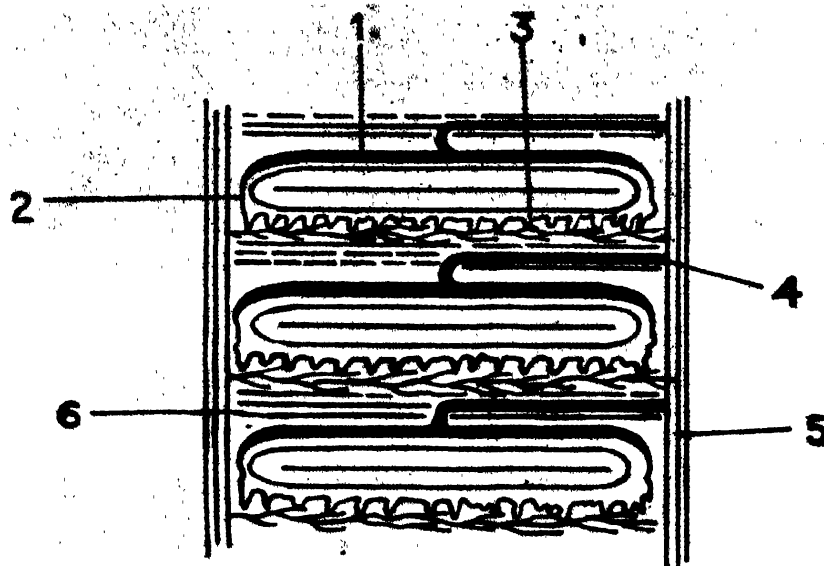


Fig. 1. Structure of electroplaques with innervated and non-innervated faces of several electroplaques in one column: 1. Myoneural junction (Synapse), 2. Electroplaque, 3. Non-innervated face, 4. Nerve, 5. Blood vessels, 6. Connective tissue

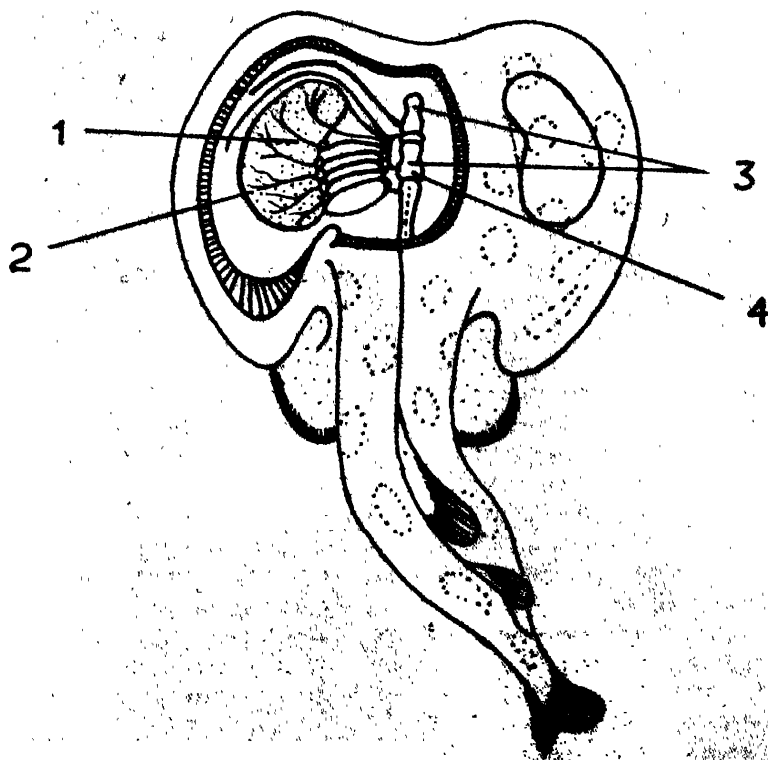


Fig. 2. Torpedo showing electric organ; 1. Electric organ, 2. Vagus nerve, 3. Brain, 4. Electric lobe of brain

electroplaque and are embedded in a jelly like matrix. Each electroplaque is bounded by a connective tissue in an elongate tube. One face of each

electroplaque is supplied with nerve fibres and the jelly-like substance is provided with blood vessels. The electroplaques are arranged one above the other in the form of columns in which the innervated faces are in the same direction. The columns of piles of electric cells form an organic battery which produces current just as voltage is increased by joining up storage battery.

In the Torpedo there are two large and two small electric organs (Fig. 2) on each side of the body. The small organ is placed within the large organ. Each such organ is made up of a number of vertical, hexagonal tubes, each tube has the form as described earlier. A large Torpedo (10 cm-15 cm) has about 1000 electroplates linked in series on each side of the body. In this species, electric organs are supplied by nerves originating from a special lobe of the brain. The innervated side of each electroplate in a column is negative to the other side. The current passes from the upper (positive) side to the lower (negative) side. Cells and blood vessel on the upper side release the discharge. In the electric eel there are three organs on each side. One is much larger than the other. Here electroplates run in length and occupy a major portion of the body. The organ is supplied by nerves coming from the spinal cord. In the catfish electric tissue forms a sheath covering the whole body just beneath the skin. Here electric discharge goes from tail to head region. In skates, snout fish and in other rays electric organs are small structures lying on either side of the caudal peduncle. Star-gazers have such an organ in the form of two oval patches behind the eyes.

#### Mechanism of electric current discharge

The discharge of electricity is controlled by nerve fibres which profusely branch and make a large

number of synaptic contacts with one face of electroplaques. Many electroplaques as described earlier are grouped to form columns or piles. The innervated face of all the electroplaques lie in the same direction. Nerve impulses reach all the electroplaques in a column at the same moment. This results in simultaneous excitation of all the innervated sides of the electroplaque in a column. Being excited, a reversal of the membrane charge takes place and the inside of the cell membrane becomes electropositive. During the occurrence of reversal of membrane polarity on the innervated faces of the electroplaque, the non-innervated faces undergo depolarisation. However, this takes place after the completion of excitation in the innervated faces. During excitation the inside membrane of the innervated face of each electroplaque achieves around 90mV electropositively relative to the non-innervated face. So at this moment each column consists of positive and

negative 'plates' alternately. The voltage is achieved by a series of summation of the electromotive force generated by the individual cells.

The force of discharge from the electric organ of different fishes has been measured in laboratory condition : Torpedo with 40-50 volts, Eel 370-550 volts, catfish 350-450 volts.

#### Function of electric organ

Opinions differ on the functions of electric organ in different fishes. But most authorities agree that fishes discharge electric current both for defensive and offensive purposes. However, it seems reasonable to presume that different characteristics of this organ are related to different functions. Torpedo and eel immobilize the prey before devouring them by discharging electric current. Fishes which live in murky water and with poorly developed eyes (snout fish) discharge weak electric pulses unin-

terruptedly and set up lines of electric force in the water around them. If a moving object breaks this field, it is promptly detected in the 'Radar field' and the fish immediately becomes aware of it. The rate of pulses which are emitted is changed and this helps the fish to locate the object more accurately. Therefore, in these fishes electric organ acts as a warning device. This is particularly very useful during the breeding season to keep away other species while the fish seeks its mate. The exact mechanism by which the fish detects the break of the 'Radar field' is not known. However, the large development of cerebellum in the brain and the presence of certain peculiar cells at the base of the dorsal fin in snout fish may give some clue to this direction.

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## ANSWERS

### Science quiz

1. (a); 2. (b); 3. (a); 4. (c) (1901 winners received theirs a year late); 5. (b); 6. (a); 7. (a); 8. (d); 9. (c); 10. (c); 11. (c).

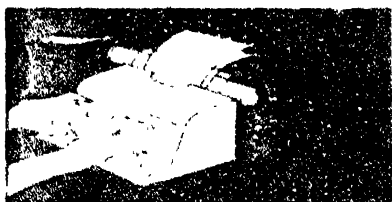
### Puzzles

1. Only in 1904. (1900 is *not* a leap year).
2. No, consider a person standing at the North Pole (South Pole). All directions from his place, point towards south (North).

He has got only one choice.

White bear lives in the north polar region, and the penguin bird lives in the south polar region.

Both will be equal in length. At the pole, the altitude of the sun remains same throughout the day.



## NEWS & NOTES

### Chemistry Nobel Laureate Stein passes away

**W**ILLIAM H. Stein, Professor of Biochemistry at the Rockefeller University, New York, who shared the 1972 chemistry Nobel Prize with his colleague, Stanford Moore and Christian B. Anfinsen of the National Institutes of Health Bethesda, Md., U.S.A., died on February 2, 1980 at his home in New York at the age of 69. Although active in research till his death, due to the degenerative nerve disease gillain-barre, Stein had been confined to an invalid's wheelchair since 1969.

According to the official Nobel award citation, Stein and Moore were awarded the Nobel Prize "for their contribution to the understanding of the connection between chemical structure and catalytic activity of the active centre of the ribonuclease (an enzyme) molecule". (An enzyme is an highly specific complex chemical catalyst.) Stein's work in collaboration with his colleagues spread over the years 1949 to 1963 led to fundamental contributions to enzyme chemistry. Working independently on the enzyme ribonuclease, Stein, developed the relationship between structure and catalytic activity of the enzyme. By 1960, Stein and Moore had essentially completed their work



Dr. Stein

on the analysis of the whole sequence of 124 amino acids in the enzyme ribonuclease. For the next twelve years, Stein and Moore did similar work on the enzyme deoxyribonuclease and a week before the announcement of the award, Stein and Moore had completed their outstanding work on deoxyribonuclease which is also

worthy of a Nobel award.

The importance of the work of Stein and his cowinners of the 1972 chemistry Nobel Prize lies in the fact that such enzyme studies may eventually lead to genetic repair or diseases control. As Anfinsen had observed: "If you want a certain catalytic job done or perhaps a replacement of a missing protein in an animal, you might be able to design in advance the three-dimensional structure."

Stein was born in New York on June 25, 1911 and educated at Phillips Exeter College, Harvard University and Columbia University. It was at Columbia that he obtained his doctorate in 1938. The same year he joined the Rockefeller Institute and later, the Rockefeller University. He also taught at the University of Chicago and Harvard University.

R. C. DHINGRA

Principal

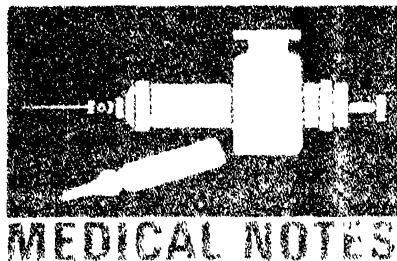
Govt. Postgraduate College

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## Fifth All India Congress of Zoology Bhopal 1980

**T**HE Fifth All-India Congress of Zoology sponsored by the Zoological Society of India will be held under the auspices of Bhopal University, Bhopal in October-November, 1980. Sections under which papers will be presented include Cell Biology and Genetics, Ecology and population studies, Hydrobiology and Marine Zoology, Experimental Zoology and Radiation Biology, Fish and fisheries, Behaviour, Toxicology, Endocrinology and Reproductive Physiology, Developmental biology, Physiology and Biochemistry, Entomology, Parasitology, Taxonomy, Environmental Biology, General

Zoology, Histology and Histochemistry and Morphology. Group discussions will be held on conservation of wild life in India and contribution of zoology to national development. A who's who of zoologists will be brought out on the occasion. Abstracts of papers to be presented should not exceed 200 words. The last date of receipt of abstracts of papers and discussion and biosketch is 30 June, 1980. For details, please write to Dr. D. K. Belsare, Professor of Life Sciences, Bhopal University, Bhopal or Dr. B. K. Behura, Professor of Zoology, Utkal University, Vani Vihar, Bhubaneswar, 751004.



## Hair dyes— are they safe ?

**H**UMAN hair, in many respects, resemble textile fibres. Realising this fact, cosmetic manufacturers do research on dyeing, washing and waving of hair. There are three types of hair dyes : (1) the so-called rinses, (2) semi-permanent hair dyes, and (3) permanent hair dyes. Rinses normally contain food dyes, basic dyes and textile dyes which are mixed with salts, acids (citric, malic or tartaric acid) and sometimes with detergents too. Some rinses may also contain optical bleachers which convert the invisible ultraviolet light from the sun into blue or violet fluorescence. They are designed to give a particular shade to the hair when applied in the form of shampoos. They can be removed by washing.

Semi-permanent hair dyes remain on the hair even after several washings. They contain certain dye intermediates. On the other hand, the change in colour brought about by permanent hair-dyes will last even longer. This is achieved by the addition of an oxidising agent (usually hydrogen peroxide) and hence they are also called oxidative-type hair dyes. Hair is first treated with dyes which penetrate the hair shaft. It is then chemically oxidised by treating with hydrogen peroxide. The dyes when oxidised are irreversibly bound within the hair. The colour remains much longer.

In recent times, the question of safety in the use of hair dyes has attracted the attention of scientists.

Dye intermediates which are used in different hair dye formulations are highly reactive organic chemical compounds. They are classified into different groups known as aromatic amines, aromatic nitroderivatives, phenols, etc. Names of some of them are given in Table I. Concentration of some of these chemicals may be as high as 4 % in some formulations. These active ingredients can be absorbed through the scalp into the blood stream. It has been shown that in the case of a particular formulation, as much as 4.6 mg of the active ingredient 2,5 diaminotoluene may be absorbed through human skin during a standard hair dyeing procedure. Metabolic products of these ingredients have been found to be excreted in urine for two days after a hair dyeing procedure. It is reported that even urine may appear black in some persons after the use of hair dyes. It is often said that beauty is skin deep; but products of beautification can certainly penetrate deeper.

The aromatic amines may react with nitrites which are always present in small quantities in our body (they are both taken in through food and also produced in the body) to form nitrosamines. Nitrosamines are known to be very potential carcinogenic and mutagenic agents. Bruce Ames and his colleagues of the University of California at Berkeley have tested as many as 169 hair-dye formulations available in the United States of America. They find that 150 of them, containing compounds shown in Table I as the active ingredients, are mutagenic in their bacterial test. Their bacterial test is one of the most widely accepted methods for detecting genetic toxicity of chemicals. Tests conducted on Japanese and British hair dyes have given similar results. Six brands of hair dyes manufactured

**Table I. Active ingredients of some hair-dye formulations**

1. 2-Amino-5-nitrophenol
2. 2-Amino-4-nitrophenol
3. 4-Amino-2-nitrophenol
4. 2,5-Diaminoanisole
5. 1,2-Diamino-4-nitrobenzene
6. 1,4-Diamino-2-nitrobenzene
7. 2,4-Diaminotoluene
8. 2,5-Diaminotoluene
9. 2-Nitro-p-phenylenediamine
10. m-Phenylenediamine
11. O-Phenylenediamine
12. p-Phenylenediamine
13. m-Toluenediamine

in India have also been tested by using Ames bacterial system. Of these, except one brand which is a hair dye stick, all the other five were found to be mutagenic. Other researchers from UK, USA and Japan have shown that many of these active ingredients can cause mutations in other organisms such as fungi and drosophila. They are also known to induce chromosomal aberrations in cultured mammalian cells (Chinese hamster and mouse) and also in human lymphocytes. Given the universality of the genetic material in all living systems (except some viruses), it is difficult to escape the conclusion that some of these ingredients may induce genetic damage in humans also.

The National Cancer Institute of the USA has conducted studies which showed that two hair dye ingredients 4-methoxy-m-phenylenediamine and its sulfate salt cause lymph gland and thyroid tumours when fed to laboratory animals. Recently it has also issued a warning that another hair dye component 2, 4-diaminoanisole and its salts should be handled as if they are human carcinogens. These warnings are based on the laboratory experiments in which rats and mice fed with these compounds, developed excess site-specific malignant tumours. However, many other carcinogenic studies with hair dye formulations and their active



ingredients using laboratory animals have revealed only conflicting results. While some studies did reveal important differences in the rate of tumour incidence (in lymphoid system, uterus and ovaries) between control and treated animals, others did not. The manufacturers, of course, have questioned the utility of feeding tests. They contend that, hair-dyes are not for eating. However, there are a number of pointers which suggest that these chemicals may be carcinogenic :

(1) in Ames bacterial test 85 to 90 per cent of carcinogens show up as mutagens. Hence the chances that the hair dye ingredients which are mutagenic in Ames test can turn up to be carcinogenic are quite high;

(2) as stated earlier, many of active ingredients in hair dye formulation are known to induce chromosomal aberration in cultured mammalian cells and human lymphocytes. Further, they are also known to induce morphological transformation in cultured chinese hamster cells. Transformation is the nearest *in vitro* evidence for cancer induction.

(3) compounds which are related in chemical structure to many of the active ingredients in the hair dyes are known to be both mutagenic in a number of test systems and carcinogenic to humans. For example, chemicals such as benzidine, 4-amino-biphenyl, beta-naphthylamine which are structurally related to many aromatic amines in the hair-dyes are known to be very potential human carcinogens, and

(4) there is also epidemiological evidence to support the carcinogenicity of hair dyes. Analysis of death certificates of residents of Alameda county in California has revealed that persons who were engaged in occupation such as "beauticians, hairdressers and cosmeticians" (separate from "barbers") had a 6 times increased risk of lung cancer compared to matched controls. Epidemiological surveys in Leeds (UK), New York and New Orleans (USA) have revealed

excess bladder cancer among hair-dressers and beauticians.

It has been estimated that a cumulative dose of hair dye chemicals absorbed in humans after 10 years of monthly hair dyeing may range between 10 mg/kg to 100 mg/kg body weight. Even though there is no conclusive human data that this dose will entail a higher risk of cancer, similar levels of a cumulative dose of the related chemical benzidine in industrial workers, has been shown to induce a statistically significant increased rate of bladder tumours. The direct association of hair dyes with human cancers will also be obscured because of the long latent period involved (hair dyes have come to widespread use only recently) and other competing factors such as cigarette smoking, environmental pollution, etc. However, laboratory and correlative evidence are strong enough to provide a warning before it is too late.

### Teratogenic effects

Teratogenic effects are those which are produced in the fetus, when the pregnant mother is exposed to a toxic agent. Even though nature has provided what is known as a placental barrier to protect the fetus from toxic effects of chemicals present in a mother's blood stream, it is unfortunately not impermeable to all toxic chemicals at all times. Some of them can penetrate the placental barrier and reach the fetal tissue. The human fetus, as it can be expected, is known to be about 50 times more sensitive than adults. Since hair dyes are used by many women and possibly during pregnancy also, their teratogenic effects have also been investigated. Earlier reports have shown that some of the semipermanent dyes were not teratogenic in rats and rabbits. However, it has recently been shown that 2-5-diaminotoluene, which is an active ingredient in some oxidative-type hair dyes, when fed a single dose of 50 mg/kg body weight on various days of preg-

nancy produced several fetal abnormalities ranging from low incidence of exencephaly and prosoposchisis to a high incidence of skeletal malformations. On an equivalent dose basis, even though this is higher by about 500 times compared with the amount of 2-5-diaminotoluene which can be absorbed through the scalp in one hair dye procedure, it should be noted that occasionally human beings are more sensitive to certain chemicals than are some experimental animals. For example, humans are 60 times more sensitive than mice and 700 times more sensitive than hamsters to thalidomide teratogenicity. Hence, such laboratory experiments, though necessarily conducted at doses higher than equivalent human doses, cannot be discarded as irrelevant when exposure of millions of human beings is involved. This is further so when we realise that human sensitivity itself varies over a wide range.

### Other cosmetic products

Stirred by the results of investigations on hair dyes, researchers of Massachusetts Institute of Technology have shown that similar hazards may exist in the use of other cosmetic products such as hand and body lotions, hair shampoos, etc. They contain a chemical called n-nitrosodiethanolamine (NDEIA). They have pointed out that NDEIA which is known to produce liver tumours in rats and many other species tested so far may be present in these products in the range of 1 nanogram/gm to 48,800 ng/gm. It is possible that a significant amount of NDEIA could be absorbed through skin.

### Legislative ban

The Federal Drug Administration (FDA) of USA has required cancer warning labels on hair dye formulations which contain as active compounds 4-methoxy-m-phenyldiamine (4MMPD) and its sulfate salt (4MMPDA). Other

formulations are under close study. However, even though the hazards of hair dyes are being discussed in the scientific literature, such legislative actions have not yet been taken by any other country, including India. It is for the individual users to take the

decision based on available scientific information.

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## **Artificial sugars and bladder cancer**

**P**REVIOUS animal and human studies implicated artificial sugars, such as saccharin and cyclamate, as potential factors for human bladder cancer. This implication has been further strengthened by a recent study of the U.S. National Institute of Cancer. In this study, some 3,000 bladder cancer patients and 6,000 other persons, matched for age and sex, who did not have the disease, were interviewed. As bladder cancer is more common in men than in women, three out of four those interviewed were men. The study found a 60% increased risk of bladder cancer in heavy users of artificial sugars, namely, persons who consumed two or more cans of diet drinks or six or more daily servings of an artificial sugar. The study also found that women who never used artificial sugars had 60% less bladder cancer than women who consumed artificial

sugars or diet drinks, and that the risk rose with the amount of artificial sugar used. Another finding of the study was that smoking, itself considered a cause of bladder cancer, was even more a risk when combined with artificial sugars; the risk seemed to be greatest in men who smoked two or more packs (each pack containing 20 cigarettes) a day and women who smoked more than one pack a day. However, the study could not pinpoint which artificial sweetener was to blame because many of the people interviewed had used both saccharin and cyclamate. Saccharin became popular when cyclamate was banned in the U.S.A. in 1970.

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## **An insulin delivery system to match blood sugar**

**F**OR treatment of diabetes, a reliable method is yet to be developed for delivery of insulin in amounts that correspond more accurately to the body's need for this hormone. The most commonly used method of delivery of insulin by daily injection is said to be relatively crude, because the dosage usually fails to correspond to the body's changing need for the hormone. Failure to regulate insulin delivery allegedly causes significant tissue damage leading to blindness, heart attack and other ailments. Recently, M. Brownlee and A. Cerami of New York's Rockefeller University invented an improved chemical method of insulin delivery. The invention involved a new chemical compound that releases insulin into the body in doses that correspond precisely to the amount of sugar in the blood. The new compound was an insulin derivative with an attached sugar maltose. Used in combination with a plant lectin, the new compound reacted to the presence of blood sugars by releasing corresponding amounts of insulin (*Science*, 206, 1190, 1979). In animal experiments, the insulin-maltose compound was nearly as effective as the unmodified hormone in lowering blood glucose.

**R.K. DATTA**



# SCIENCE FOR THE YOUNG

## The silverfish

WHILE leafing through old books, one might occasionally come across a tiny silvery insect, darting away rapidly into the interstices of the volume. All attempts to locate it will probably end in vain. *Lepisma saccharina* or the common silverfishes are household pests, included among the Apterygotan insects (insects without wings) under the group Thysanura (*Thysan*=fringe; *ura*=tail).

### Habitat

They are mostly found in cool, damp places. They shun light and are very fond of starchy and sugary matter. Even though they are minor pests, they do pose a threat to housewives who have a tough time getting rid of them.

### Structure

They range in size from 2 cm to 4 cm. The body is elongated, spindle shaped and depressed. They are silvery grey in colour almost harmonising with their surroundings. The body is uniformly covered with gleaming scales. The head bears reduced compound

eyes and long filiform antennae. They possess chewing mouthparts. They are also known as bristle-tails, because of the three slender appendages emanating from the rear of the abdomen. Small rudimentary legs are borne at the sides of the abdomen. These legs are in the form of protuberances (styli) and may often have vesicles which are thrust out, by means of blood pressure. It is believed that moisture is taken up through them.

### Life history

The reproductive system and the behaviour associated with it, makes fascinating study. The sexes are separate.

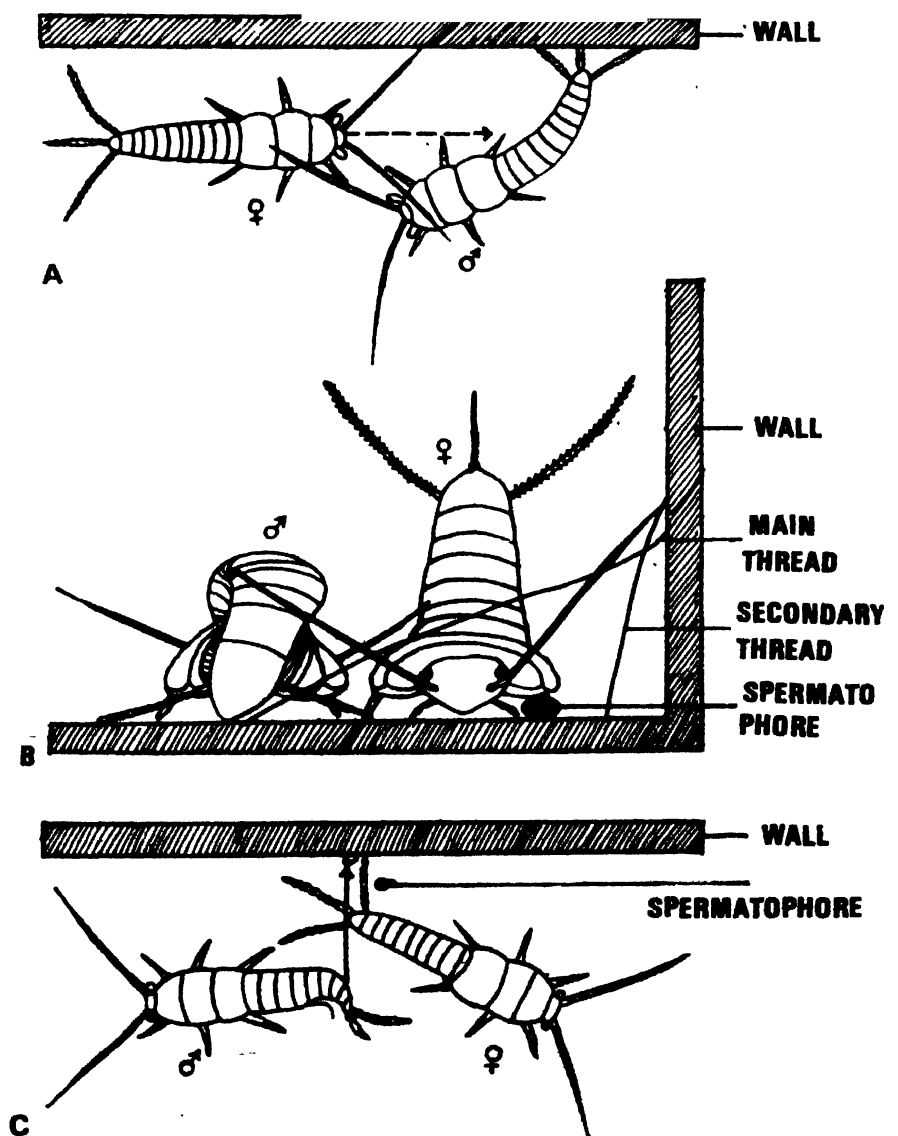


Fig. 1→

In most of the species of *Lepisma-tidae*, the males are far less common than females and apparently new individuals are produced frequently from unfertilised eggs by the process of parthenogenesis.

Silver fishes exhibit an elaborate and bizarre pattern of courtship. The male attracts the attention of his partner by brushing past his body against her legs which at once responds to this overture. Gradually he guides his partner to a spermatophore (a case or capsule containing spermatozoa) which he has previously deposited on the substrate. The spermatophore is linked with a series of threads (Fig. 1) which restricts the movements of the female. The female which has been stimulated by the brushing action, finally seizes the spermatophore by her genitalia. Sexual rivalry is not uncommon. The male *lepisma* often fights over a female.

Sexual maturity is reached within a year or so. The eggs are relatively large and are laid singly in cracks and crevices, mostly out of sight. They are often disguised by tiny bits of craps that stick to them.

Metamorphosis is less. The young ones that hatch out from the eggs resemble the adults, except in size and in minor details like absence of scales, styli and external genitalia. An interesting feature is their post-

imaginal ecdysis, that is they grow and moult even after maturity. The female lays a batch of eggs and moults again. Continuing in this way, alternately moulting and laying eggs, she will moult upto 50 times and will increase three times in size.

In the tropical species the life cycle is shorter being about a year and the insects may pass through 6 or more instars (nymphal stages) whereas for those in temperate zones it may be two or more years. Incidentally, the longevity in most investigated species ranges from one to four years. This depends upon environmental conditions and is of course variable from species to species.

### Control measures

Unless precautionary steps are taken, these insects will multiply and become a nuisance. They can be eradicated by applying contact poisons. Insecticides like Sevin, Gammexane, D.D.T. have proved to be fruitful.

All said and done, ignoring their destructive nature, a biologist would welcome one and observe its fascinating ways for hours together.

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## Gregor Mendel, the Geneticist (1822 - 1884)

THE most interesting topics in biology are related with the genetic principles of transmission of characters from parents to offsprings. How character transmission occurs from generation to generation was for the first time clearly described by Gregor Mendel—an Austrian monk from his experiments on peas. His two

laws of inheritance—(i) the law of segregation, and (ii) the law of independent assortment together with some less fundamental generalisations about dominance and recessiveness—are now firmly established in biology. The law of segregation which has been deduced from crosses of pea strains differing in one contrasting character

states that when a pair of alleles (forms of a gene) is brought together in hybrid union, the members of the allelic pair do not blend and separate out when the hybrid forms gametes. In other words, the gametes (reproductive cells) are pure and contain only one of the alternate forms of a gene, e.g., tall vs. dwarf. This is also called the law of purity of gametes. The second law was deduced from observations on two characters at a time. It states that the factors for the two or more alternate pairs of characters are segregated at the time of gamete formation independently of each other and these gametes unite at random at the time of fertilization forming all possible combinations.

Gregor Johann Mendel was born on July 22, 1822 in Heinzendorf, a village in the Subeten region of Silesia, at that time, a part of the Austro-Hungarian Empire now in Czechoslovakia near the Polish borders. He was the second son of a farmer. This area had been populated by the German and Czech ancestry, living side by side who used to intermarry. Mendel had this mixed ancestry Johann or Hansl, as he was called when young, used to work with his father Anton Mendel in grafting the fruit trees. While helping the father he used to ask questions. In the words of Hugo Iltis, the incidence at the age of 10 (in 1832) goes like this. "Father, our teacher, Mr. Makitta, taught us today that the tree upon which you graft does not change the scion. A small scion from a noble variety will grow into large branch and will bear fine fruits even if it gets all its food from a poor stock. I can't understand how this can be." The father also did not know the phenomenon underlying this process. Such thoughts of the childhood remained anchored in Mendel's mind and years later shaped his way of thinking.

Mendel received his elementary school education at his village. He was sent to elementary school at Leipnik, thirteen miles away from his



Gregor Mendel

village, at the age of eleven. He topped in this school and later in 1834 joined the High School at Troppau—more than 20 miles away from his village. For some time while he was at this school, he had to leave studies to earn expenses. He completed his six year schooling and later graduated with an excellent record in August 1840. With the financial help of his sisters and from private tuitions he completed his two year course at Olmutz Philosophical Institute. In October 1843, he was admitted as a novice at the Augustinian monastery at Brunn in Moravia. Four years later, he became a priest. During this time he was not too busy, with his classical and theological studies, so he developed interest in natural sciences. In 1848, he completed his theological studies and one year later was appointed a substitute teacher in the high school at Znaim. Here he taught Greek and elementary mathematics. On the prompting of his chief and colleagues, Mendel in 1850 took an examination for a teaching certificate in science, but failed. It is thought that the examining board was biased because he was a priest or because his scientific views were unorthodox, but it is more likely that he was not adequately prepared. This committee of

professors of Vienna University recommended more training for him; consequently the abbot of monastery allowed him to enter the University at Vienna as a student. He spent four terms from 1851-1853 at the University and studied physics, chemistry, mathematics, zoology, entomology, botany and paleontology. His teachers of physics, mathematics chemistry and botany were all productive research men. This mathematical background led to application of mathematics to biology by him.

Mendel came back to Brunn after the summer of 1853 and began his career as a teacher in physics and natural history in the Brunn Modern School. In 1856 he again took up the teacher's certificate examination but failed because, according to Iltis, he was offended in the oral examination from which he withdrew. This incidence tells us his independent way of thinking. He was a popular teacher and his school authorities continued his services for twelve years as a supply teacher. Later, he was elected abbot.

Mendel's scientific pursuit began in 1854 when he grew 34 strains of peas which he tested for their constancy of characters in 1855. A year later in 1856 he started his famous hybridization programme on peas. According to him, his experiments with peas were prompted by the results obtained from artificial fertilization of ornamental plants in order to produce new colour variants. He also worked on bees and mice but never published his results on mammalian genetics.

The experiments on edible peas were continued up to 1863. He carried out his breeding experiments in monastery garden. Mendel delivered his first report before Brunn Society of Natural Science on February 8, 1865 concluding it in the March 8, 1865 meeting. This paper was published in the Society's proceedings in 1866. The proceedings were exchanged with 120 other societies, universities and

science academies. When Mendel read his paper before the society there were no questions and no discussions inspite of the presence of Secretary of the Society, Gustav von Niessl—astronomer and botanist and many other able scientists of the time. Mendel's mathematical description of hereditary phenomenon which could be tested and retested was strange to the audience. In fact the time was not ripe to understand Mendel's discovery. During the following 34 years, not one man appreciated his contribution. a rather surprising happening for the discovery of one of the most important laws of nature.

Our information about Mendel's work from 1865-1873 is derived from his letters to Carl von Nageli between 1866-1873. These letters were obtained from Nageli's family and were published by Carl Correns (1905) a pupil of Nageli. However, Nageli's letters have been lost but there are ten such letters from Mendel to Nageli. When Nageli was Professor of Botany at Munich, Mendel sent him a copy of his famous 1866 paper together with a letter stating that he is continuing with his work on the plants of interest to him, i.e., *Hieracium*, *Cereium* and *Geum*. Nageli did not appreciate Mendel's work and never made a reference about him in his publications. The work on *Hieracium* prompted by Nageli who also supplied the seeds was a great disappointment to Mendel. He concentrated for 5 years on the genetics of the plant. He published his paper on *Hieracium* in 1869 which appeared in the proceedings of the Brunn Society in 1870. He also wrote to Nageli on July 3, 1870 that "On this occasion I cannot resist remarking how striking it is that the hybrids of *Hieracium* show a behaviour exactly opposite to those of *Pisum*." The fact underlying his failure was not clear till 44 years later when Swedish investigators reported that *Hieracium* reproduces apomictically and hence the hybrids do not show any segregation. In addition, Mendel also studied his

genetic principles on several other kinds of plants in which he confirmed his laws but his failure with *Hieracium* and the encounter with Nageli ruined his career as an investigator.

Mendel accepted Darwin's theory of natural selection and evolution. But to him evolution resulted from the combination and recombination of hereditary elements. He added to Charles Darwin's theory the most important material for evolution, i.e., the variations resulting from hybridization on which struggle for existence and survival of the fittest operates.

Not only that Mendel worked for the discovery of inheritance principles, he was also interested in meteorology. He continued to record rainfall, temperatures, humidity and barometric pressure to the end of his life. In 1870 he published a detailed account of Brunn tornado giving physical interpretations but it is all the more astonishing that this paper also was not given due recognition by academicians.

Last years of Mendel's life were spent in controversy with the government on taxation of monastery property. He fought for it to death after which compromise was worked out. Though Mendel continued taking note of meteorological and horticultural observations but his scientific work was practically over by 1871 because of his administrative responsibilities as head of monastery since 1868. Mendel died on January 6, 1884 of Bright's disease. He was buried in Brunn Central Cemetery on January 9, 1884.

Till the life span of Mendel, his work, either administrative or scientific, did not bear fruit. But later his laws were rediscovered by three scientists in 1900 simultaneously and independently after which his famous paper of 1866 was universally accepted. Mendel's discovery provided a stimulus to all biological branches particularly genetics. Since his laws are applicable to all living creatures including human beings, therefore all organisms following Mendelism are Mendelized

and hence Mendel has become immortal so long science lives. However, as has been the procedure of the people a monument was raised depicting Mendel as a priest standing in front of peas and beans and with out-stretched hands, fingering flowerings and leaves. Down below the statute is the inscription :

To the Investigator  
P. Gregor Mendel  
1822-1884

Below this is written : Erected in 1910 by the Friends of Science. Between these inscriptions is the figure of a woman and youth, who are nude and kneeling. This depicts the importance of Mendel's genetic principles having an impact on human life also.

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## Amoeba

ALPHABETS begin with the letter A,  
I start and end with Big and small 'a'.  
*Amoeba* my name, proteus my fame,  
Form and shape is never the same.  
Of Global bios, I am ABC,  
My brother in your blood is WBC.  
I am protos, I am a zoon,  
With the rains I am active soon.  
I was born when you were out of scope,  
And still you require the microscope!  
I am plasma, sol and gel,  
Call me or not a single cell.  
Colourless, shapeless, I am like God,  
Eating without mouth, walking pseudopod.  
No love affair, no submission,  
I prefer the way of binary fission!  
I don't require a partner in my Life,  
I produce two daughters without any wife!  
I avoid light, chemicals I hate,  
Touch me not, earth is my fate.  
Call me rhizopod, or a sarcodine,  
Higher than flagellates, idea is fine!  
Howsoever advanced, men are mortal,  
Though primitive and simple, 'am immortal.

Proteus —a Greek goddess capable of changing her shape  
Bios —life  
WBC —White blood corpuscles (cells)  
Protos —first  
Zoon —animal  
Pseudopod —false foot  
Rhizopoda, Sarcodina and Flagellata—zoological names of classes of Protozoa  
which includes very simple, mostly unicellular animals  
Plasma —protoplasm, the living fluid

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## Puzzles

1. The date of birth of Morarji Desai, the former Prime Minister, is 29.2.1896. When would have he celebrated his *first* birthday?
2. A saying is "every man has got 4 choices of directions—East, West, North and South—to proceed further from the place where he stands." Is it true for all places?
3. White bear and penguin bird live in polar regions. The white bear does not hunt and eats penguin bird though it is a non-vegetarian. Why is it so?
4. You are standing at the North Pole. Which of the shadows cast by you—one at 12.00 noon and another at 12.00 p.m.—will be greater in length?

G. ARIVARIGNAN  
Asstt Professor of Statistics  
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## Science quiz

1. First element in the Mendeleev's periodic table is hydrogen and the hundredth element is
  - (a) Fermium
  - (b) Mendelevium

- (c) Nobelium
- (d) Einsteinium

2. The element Mendelevium named after Dmitri Mendeleev, who devised the periodic table has the atomic number

- (a) 100
- (b) 101
- (c) 102
- (d) 99

3. Radioactivity was first discovered by

- (a) A. Henri Becquerel
- (b) Pierre Curie and Marie Curie
- (c) Wilhelm Roentgen
- (d) William Bragg

4. The Nobel medals were first minted in the year

- (a) 1895
- (b) 1900
- (c) 1902
- (d) 1903

5. Albert Einstein won Nobel prize for his work on

- (a) Theory of Relativity
- (b) Photoelectric Effect
- (c) Formulation of mass and energy relationship,  $E = mc^2$
- (d) Brownian motion

6. Sir C.V. Raman won Nobel Prize for his work on

- (a) Diffusion of light
- (b) Nuclear physics and cosmic radiation
- (c) Cathode rays
- (d) Discovery of wavelength change in diffused x-rays

7. The only person ever to be honoured twice with Nobel Prize in science is

- (a) Marie Curie
- (b) Pierre Curie
- (c) Irene Joliot Curie
- (d) Linus Pauling

8. Disintegration of nitrogen into oxygen and hydrogen upon bombardment with  $\alpha$  particles was the first nuclear reaction observed by man. The experiment was carried out by

- (a) Neils Bohr
- (b) James Chadwick
- (c) Werner Heisenberg
- (d) Lord Rutherford

9. Uranium nucleus was split for the first time by

- (a) Einstein
- (b) Rutherford
- (c) Otto Hahn
- (d) Lise Meitner

10. On December 2, 1942 the first self-sustaining chain reaction was achieved and thereby initiated the controlled release of nuclear energy. At that time the research team was guided by

- (a) Einstein
- (b) Glenn Seaborg
- (c) Enrico Fermi
- (d) Ernest Lawrence

11. The first atomic explosion was set off in 1945 at

- (a) Hiroshima, Japan
- (b) Nagasaki, Japan
- (c) Alamogordo, New Mexico
- (d) Research laboratory at Chicago University, USA

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(See page 341 for answers)



# FOR HER

## Perfumes

**F**RAGRANCE makes a major contribution to the cosmetic industry. The Egyptians and ancient Hebrews used them for both personal and religious purposes. During Roman and Greek civilizations, their importance reached such a height that a special perfume was required for each part of the body and a gift of rare perfumes was a sure way to win the royal favour. The perfumes owe their importance due to their considerable hygienic as well as aesthetic value, for they act as true antiseptics and deodorants.

The word 'Perfume' is derived from the Latin word 'perfumare' which means "to fill with smoke." The use of perfumes is assumed to have originated in Egyptian temples where powdered spices were used as incenses. Subsequently the flower petals were steeped in oils or fats when the latter would retain a portion of the odoriferous principle. Later various odoriferous principles were blended together to create an acceptable fragrance and hence started the perfume industry. In its present shape a perfume may be defined as any mixture of pleasantly odoriferous substances dissolved in a

suitable solvent popularly known as a vehicle. Formerly most of the products used in perfumery were of natural origin. The tendency afterwards was to duplicate them by various synthetic methods. The consumption of natural products is increasing inspite of the many synthetic substitutes that the chemist has put on the market. The main objectives of synthesizing these incenses was (a) to enhance the natural perfumes, (b) to reduce the price and (c) to introduce new notes of fragrance into the commonly available perfumes.

### Constituents

There are three main constituents present in a perfume. The vehicle or solvent—which is usually a highly refined form of ethyl alcohol, mixed with water according to the solubilities of the oils employed. An ideal solvent is considerably volatile so as to help in projecting the scent it carries, it is fairly inert and is also soothing and non-irritating to the human skin. By adding a small amount of gum benzoin, the natural rawness and slight odour of alcohol is modified or taken away.

### Fixative

When the perfume substances are dissolved in alcohol the more

volatile components will evaporate faster and hence the perfume will consist of a series of impressions rather than a fixed desired ensemble. To overcome this problem, fixative is added which alters the rate of evaporation of the odoriferous principles present in a perfume. The fixative may or may not contribute to the odour of the perfume but is normally less volatile than the active principle and hence delays and equalizes evaporation. Of the most widely used fixatives is an animal product 'Castor'. Castor is a brownish-orange exudate secreted by the perineal glands of the beaver. This volatile oil is odoriferous due to benzyl alcohol, acetophenone and 1-borneol. 'Civet' developed in Ethiopia is another soft fatty secretion of the perineal glands of the civet-cats. The crude civet carries a disagreeable odour but aging and dilution renders a sweet floral odour to it, due to the formation of cyclic ketone, Civetone (Fig. 1-I). Another cyclic ketonic principle 'Muskone' (Fig. 1-II) is derived from the preputial glands of the male musk deer. Musk is the most useful of animal fixatives. 'Ambergris' is another well-known animal fixative obtained as a secretion of certain whales. Musk Zibata is a newest animal fixative which is obtained from the musk rat.

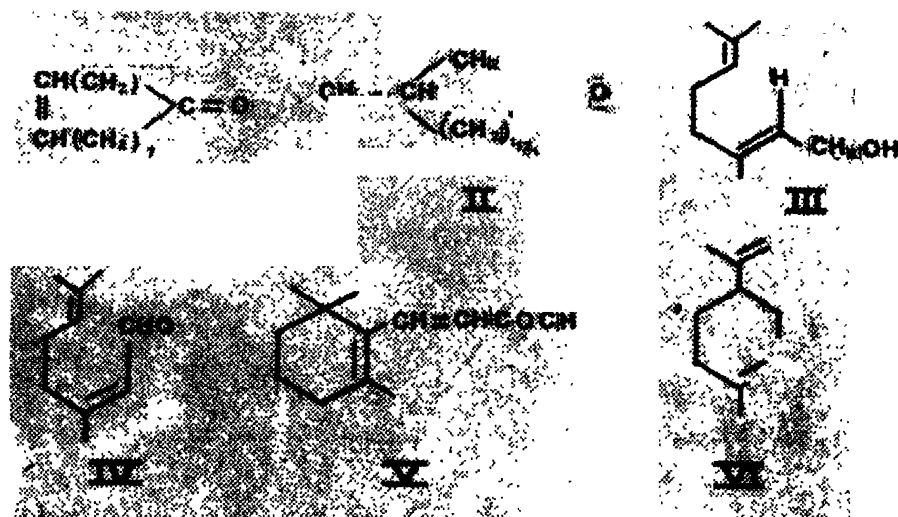


Fig. 1



Resinous fixatives derived from certain plants include normal resins and also the pathological exudates like hard resins—benzoin, gums; softer resins—Myrrh, labdanum, balsams; oleoresins and some oily materials having terpenic constituents. Fixatives derived from various essential oils include sandalwood oil, synthetic fixatives, high boiling odorous esters like glycerylacetate, ethylphthalate and benzyl benzoate (boiling points 259°C, 295°C and 323°C respectively). Out of the odorous fixatives, esters of cinnamic acid, amyl benzoate, vanillin, acetophenone, benzophenone and certain coumarins need a special mention.

**Odorous principle.** The odorous principle which constitutes the major effective part of perfume composition may be derived from (a) essential oils, (b) isolates (c) semi-synthetic and (d) synthetic chemicals. Essential oils are volatile odoriferous substances of vegetable origin. Natural flower oils are obtained by solvent extraction method and the essential oils by distillation.

Some of the important and highly priced perfume oils are the 'otto of roses', Geranium oil, ylang-ylang, oil of citronella, lemon-grass oil, oil of vetiver, oil of sandalwood and the Lavender. The 'otto of roses' is commonly known as 'attar' or rose oil. This is still one of the favourite perfumes either alone or in combination. The flowers are picked in early morning just as they are opening and are distilled as soon as possible. The oil is colourless in the beginning but turns

yellow or greenish gradually. About 9,000 kg of flowers are required to make .45 kg of the essence which is worth Rs. 1500. Very little pure otto reaches the market, for it is almost always adulterated with geranium or palm rosa oil which also have a rose-like odour. Geranium is obtained from the leaves of several species of Pelargonium. Ylang-ylang is an important oil in the perfumers' art and is a constituent of almost all the perfumes. The name means 'flower of flowers.' The oil, having exceedingly delicate and evanescent fragrance is derived from the yellow green bell shaped flowers of *Cananga odorata*. Both bitter and sweet oranges are yet another source of perfumes. The orange oil is obtained by expressing the ripe peelings. The leaves of *Cymbopogon nardus* yield a sweet smelling insect repellent oil known as the oil of Citronella which comprises of 80%-90% geraniol (Fig. 1-III). The leaves of *Cymbopogon citratus* yield a reddish yellow oil with a strong taste and odour due to the high 70%-80% of Citral (Fig. 1-IV). This oil is extensively used in perfumes, cosmetics and toilet preparations. The rhizomes of *Khushkus* plant on distillation give the oil of vetiver which is much similar to citronella in fragrance.

Lavender is a very old perfume and is still one of the most popular perfumes. The oil is an important constituent of 'Eau-de-Cologne' and other high grade perfumes. Lavender water, a mixture of the oil in water and alcohol is a highly popular toilet article in England. The blue and violet flowers of violet on

maceration with hot fats yield the violet perfume. Real violet perfume is rare and expensive and it has been almost entirely replaced by synthetic Ionone (Fig. 1-V) analogs. Distillation of sandalwood (*Santalum album*) yields the *Chandan* oil which is an excellent fixative and is much used in blends. Patchouli is another perfume obtained from the fleshy leaves and young buds of *Pogostemon cablin*. The dark brown oil has a powerful odour resembling that of sandalwood. It is also a good fixative for heavy perfumes. The characteristic odour of Kashmiri shawls is due to this, because the shawls are normally shipped in patchouli scented containers.

Jasmine, carnation and rosemary provide the least expensive and most refreshing odours used in Eau-de-Cologne. All these oils are immiscible with water but dissolve in organic solvents readily. In most of the oils there is a large quantity of terpenes. This is especially significant in the case of lemon and orange oil with as much as 90% d-limonene (Fig. 1-VI). These terpenes present in excess oxidize and polymerize rapidly on standing and emanate a strong terpenine like odour. Hence removal of terpenes is important because they also render a cloudy appearance which is cleared up only with a great difficulty. Very frequently one notices the label of 'tsf' on perfume containers which means terpene and sesquiterpene-free.

S. BHANUMATI  
S. NARAYAN  
S.C. CHHABRA

# Science in Industry

## Cervical dilator Isaptent

**T**HE Central Drug Research Institute (CDRI), Lucknow, has developed a cervical dilator, Isaptent, an aid for termination of pregnancy and for gynaecological operations. The annual demand for cervical dilators is estimated at 5 lakh pieces.

The CDRI process consists in granulating isapgol (*Plantago ovata*) seed husk and compressing it into cores of appropriate size and encapsulating the cores in a cloth tube either lined inside with a desired paper or coated with a thin film of microcrystalline cellulose. This is followed by compressing the tube, packing it in a glass or polythene tube and sterilization.

CDRI has made more than 3000 pieces of Isaptent and supplied them to several clinical centres for evaluation. The results of tests in more than 500 cases available so far show that a satisfactory degree of cervical dilation is achieved. Not a single failure

has been reported. Psyllium seed husk has the property of swelling up at least 6 to 7 times the original bulk when it comes in contact with water. This property has been utilized for the preparation of the product. The gum present in the seed husk provides natural lubrication.

The main raw material is isapgol seed husk. About 500 kg of isapgol seed husk will be required to make 5 lakh dilators. Gum acacia, cellulose powder, fine cloth and cotton or polyester thread are also required.

A core making machine (electrically operated), a sewing machine, ovens, an applicator for applying cellulose coating, cotton or polyester thread, a compressing machine and a gamma radiation equipment are the equipment required.

The suggested optimum plant capacity is 5000 dilators per day. A total capital investment of Rs. 10 lakh would be required (fixed capital on building, Rs. 2 lakh; capital on plant, Rs. 3 lakh; and working capital, Rs. 5 lakh). Land requirements for building and storage of raw materials are 10,000 ft<sup>2</sup> and 5000 ft<sup>2</sup>. Cost of production is estimated at Re. 1 per dilator.

## Acrylic resin emulsion

**T**HE Central Leather Research Institute (CLRI), Madras, has developed a process for the preparation of an acrylic resin emulsion, designated as Binder RS. The emulsion is used as a binder in finished leather manufacture. It is an important chemical for the leather auxiliary manufactures. The demand in India for this

binder is estimated to be 400-500 tonnes/annum; half of this demand is being met at present through indigenous production and the rest through imports.

The CLRI process is quite simple as it requires only a stainless steel reactor with stirring and heating facility. A mixture of acrylic monomers in aqueous media and persulphate, which is the catalyst, along with emulsions is copolymerized to obtain the acrylic resin emulsion.

The process has been developed on a laboratory scale and the product has received satisfactory acceptability from consumers like Calico Chemicals. The product conforms to IS specifications. Small quantities of the sample may be obtained from CLRI for assessment.

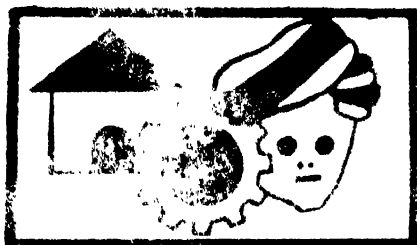
The main raw materials required are: acrylic ester monomers (Commercial grade), potassium persulphate (pure grade) and emulsifiers (nonionic and anionic, commercial grade).

The raw materials are not indigenously available and have to be imported.

The main equipment is a stainless steel reactor with provision for delayed addition, stirring and heating. This can be easily fabricated indigenously.

The capacity of an economical unit is estimated at 500 kg of the emulsion per day (two shifts). The capital outlay for such a unit is as follows: fixed capital, Rs. 1,15,000 (Rs. 40,000 for building and Rs. 75,000 for plant and machinery); and working capital, Rs. 5,00,000. The cost of production is estimated at Rs. 15/kg.

The process has a high profitability. No effluent or pollution problem is associated with the process. The plant is not power intensive and can be operated with a few people.



## TECHNOLOGY FOR VILLAGES

### Digital grain moisture meter

**T**HE Central Scientific Instruments Organisation (CSIO), Chandigarh, has designed and developed a prototype of a moisture meter to estimate moisture content in grains.

The presence of moisture in grains poses problems for agriculturists and grain dealers. Storage loss is high and storage life is low if the moisture content of the grain is high. Also, milling operation tends to be difficult and unsatisfactory if the moisture content is high. Hence the determination of moisture content is important to those engaged in the production and distribution of grains.

The principle behind the device is that the grains have a dielectric constant which varies with the moisture content of the grains. The variation in the dielectric constant is used to vary the effective capacitance of a suitable capacitor assembly. By measuring this capacitance it is possible to indicate the moisture content of the grains.

The device is based on integrated circuits (ICs) and the final readings of moisture content are given on a

3-digit light-emitting diode (LED) display in percentage. The device can measure over a range of 5%-30% (accuracy  $\pm 0.25\%$  ( $\pm 1$  digit)). An automatic temperature-compensating arrangement is also included to make the measurements independent of the variations in ambient temperature.

As the device is assembly-oriented, production equipment are not significant. However, for testing, the following equipment are required : oscilloscope, oven, analytical balance, power supply, oscillator, frequency counter, LCR bridge, multimeter, stabilizer and variac. All are available indigenously.

The components required for the fabrication of the device are : ICs, LEDs, transistors, diodes, zeners, thermistors, inductors, resistors, capacitors, crystals, transformers, PCBs and chassis. All except ICs are indigenously available. The ICs can be directly imported or procured through the Electronics Trade and Technology Development Corporation Ltd. of the Department of Electronics.

For manufacturing 300 meters per annum, a fixed capital (excluding land and building) of Rs. 0.45 lakh and a working capital of Rs. 1.5 lakh are needed.

### Refined cocoa mass

**T**HE Central Food Technological Research Institute (CFTRI), Mysore, has developed technology for the production of refined cocoa mass, both in the form of blocks and granules. The product is an important ingredient in confectionery, bakery products and icecreams. For production of cocoa mass, properly fermented and dried cocoa beans are graded, roasted batchwise under controlled conditions, deshelled, ground in a roll mill, tempered, moulded, cooled and packed in aluminium foil. The refined mass can also be cooled, granulated and packed in tins.

The machinery required for the production of cocoa mass include bean grader, roaster, bean breaker, shell

remover, grinder, roller mill, tempering units and moulder or granulator, all these items can be fabricated in the country.

India's current annual cocoa production is estimated at about 500 tonnes, as against the domestic demand of about 2000 tonnes. However, it is anticipated that the production will touch 20,000 tonnes within a few years. A share of the world market can be achieved by developing the cocoa processing industry based on indigenous technology.

To boost the development of cocoa industry, CFTRI had earlier standardized the conditions for fermentation and drying of cocoa beans, which form the raw material for cocoa products.



**MODERN PHYSICS** by Sehgal, Chopra and Sehgal, *Sultan Chand & Sons*, 4792/23, Daryaganj, New Delhi-110002 (1980). Pp. 410. Rs. 15.00

THE book deals with some aspects of contemporary physics starting from the theory of relativity which forms the introductory chapter. Most other chapters are excerpts with some inclusions and deletions here and there from an earlier book, *Basic College Physics* written by the same authors. Some of the chapters, especially the one on Electronics, are verbatim reproduction from the same book. One wonders what was the necessity of bringing out yet another book! The presentation of the text material also leaves much to be desired. Even the introductory chapter is not properly written. The authors did not care even to define what is an inertial frame which is so integral to the study of theory of relativity. Somewhere in the same chapter the authors use the phrase "we imagine the velocity of light to be infinite ( $c \rightarrow \infty$ ).". This is totally unmeaningful as the velocity of light has always a finite value. It is only in the non-relativistic limit ( $V \ll c$ ) that it can be very large as compared to the velocity of a material body or a reference frame. So the book needs a thorough revision without which it will fail to meet the requirements of those students for which it is meant.

P. K. MUKHERJEE

**THE GROWTH OF LOGICAL THINKING IN SCIENCE DURING ADOLESCENCE** by Narendera Vaidya, *Oxford and IBH Publishing Co.*, New Delhi, 1979, Pp. 215 +xx, Rs. 15.00

REALISING the importance of education in the fabric of the Indian Union, three education commissions, namely, the Radhakrishnan, Mudaliar and the Kothari commissions were set up in the last three decades. Various colleges of education and an organisation like the National Council of Educational Research and Training are entrusted with the task of bringing about improvements in the methods of imparting education to the school children. Even with all these efforts, the results are not as good as one would have liked them to be.

One of the ways of effective teaching is to inculcate the habit of thinking among school children. For this a knowledge of the growth of thinking among them is a necessary input. The book in question is an attempt in this direction. It is based on a research study for a Ph.D. degree carried out on 200 school children (100 boys and an equal number of girls) studying in grades VI to X. The students are provided with 17 problems and their methods of problem-solving are analysed according to 87 processes of thinking.

The study reported in the above book may prove to be of use to researchers in the field of education and to the students of educational training colleges. To teachers, who may wish to use the results of this study in their day-to-day class work, the book may not prove very useful as it is not written in a straightforward and lucid style.

NARESH KUMAR

**NUMERICAL PROBLEMS IN CHEMISTRY** by N.N. Sarin, and R.N. Sarin, *Sultan Chand and Sons*,

4792/23, Daryaganj, New Delhi-110002, Pp. 545, Rs. 12.50

THE book under review is meant for students preparing for Higher Secondary, Pre-University, Intermediate, I.I.T. entrance examination and other equivalent examinations. In this 14th edition four new chapters have been added to bring the book up-to-date. The chapters are : (a) Measurements, Significant Figures, Uncertainty Principle and Some Basic Concepts, (b) Oxidation-Reduction Reactions (Modern Concept); (c) Thermochemical Calculations; and (d) Electrochemistry. In each chapter the authors have given a brief account of the theory which is followed by principles involved in solving related problems. The authors have solved typical examples and have given a set of problems in each chapter. In addition, there is a separate chapter at the end of the book wherein sets of problems, both solved and unsolved, have been given. Wherever necessary the authors have explained the steps in the solution of problems. Many of the problems, both solved and unsolved, have been taken from the latest papers of Universities, Boards, I.I.T. entrance examinations, etc., to satisfy the different needs of the students. The language used in the book is easy to understand. However, there are some avoidable printing mistakes.

P. SUNDERARAJAN

**QUANTUM MECHANICS** by S.L. Kakani and H.M. Chandaliya, *Sultan Chand & Sons*, 4792/23, Daryaganj, New Delhi-110002, Pp. 652, Rs. 27.50.

QUANTUM Mechanics is the branch of physics which is essential to the understanding of the behaviour of crystals, molecules, atoms, atomic nuclei and elementary

## BOOK REVIEWS

particles. Otherwise, also, the subject is important to the students of B.Sc. (Honours) and M. Sc. Realising the need of students, Kakani and Chandaliya have brought out this book which is suited not only for B.Sc. (Honours) and M.Sc. students of physics of Indian Universities but also as a reference book. The book may also be useful to those doing research in elementary particle physics.

The book develops the subject systematically. It starts with the basics of quantum mechanics and ends with relativistic wave equations. The subject matter is the same as is available in all the well-known books on the subject. The solved numerical examples in each chapter as well as the "suggested readings" at the end of each chapter will no doubt be of much help to the students. The summary and the problems at the end of each chapter have made the book more useful to the students.

The chapter on angular momentum appears more intelligible than as is presented in many other books on quantum mechanics. In most chapters, the various equations have been solved in so much details that the reader may not find much use of his pen and paper. The appen-

dices at the end of certain chapters certainly add to the value of the book. The language in which the book has been written is simple and suits to the background of an average Indian student.

The price of the book is no doubt less compared to those written by foreign authors. However, it does not suit an average student's pocket. The elementary mathematical steps could have been avoided and the size and cost of the book reduced. The authors should have given an errata.

SUBRATA CHAKRABARTY

**BIOLOGICAL CLOCKS** by Manorama Jafa, *Publications Division, Super Bazar, Connaught Circus, New Delhi-110001*, Pp. 23, Rs. 9.25.

THE number of Indian scientists who have attempted to acquaint the laymen with latest scientific ideas through books can be counted on fingertips. Still less are those who would care to acquaint a child or a teenager with the fascinating world of science. In fact, nobody understands that it is easier to lure a young mind into science rather than a grown-up individual, who has already developed an allergy for

science. The result is that our markets do not contain any low-priced science books especially meant for our children. In this background, the book under review is welcome. The author, Mrs. Manorama Jafa, is not a scientist, but is a well-known writer in children's literature. She has consulted many Indian scientists working in the field to write this book, and she has done her home-work remarkably well.

"Do not disturb the plant. It is sleeping", warned the author's mother when she touched a plant during a garden walk at night. This was the author's first introduction to biological rhythm. Subsequently, she came to know of various other biological phenomena, which urged her to know more of biological clocks. Similar urge must today be persisting among the young minds, and so this book would give them a brief idea of what it is all about. The style of narration is simple and direct, which makes the book immensely readable for both children and laymen.

Well illustrated and nicely produced, the price of the book is, however, too high. In particular, why this 23-page book should be hard-bound, the reviewer fails to understand.

DILIP M. SAIWAL

## Books received

1. **BIOLOGICAL APPLICATIONS OF SOLAR ENERGY** Ed. by A. Gananam, S. Krishnaswamy and Joseph S. Kahn, *Macmillan Co. of India*, 2/10, Ansari Road, Daryaganj, New Delhi-110002, pp. 214, Rs. 75.00.
2. **FROM FLOWER TO FRUIT** by B.G.L. Swamy and K. V. Krishnamurthy, *Tato McGraw*

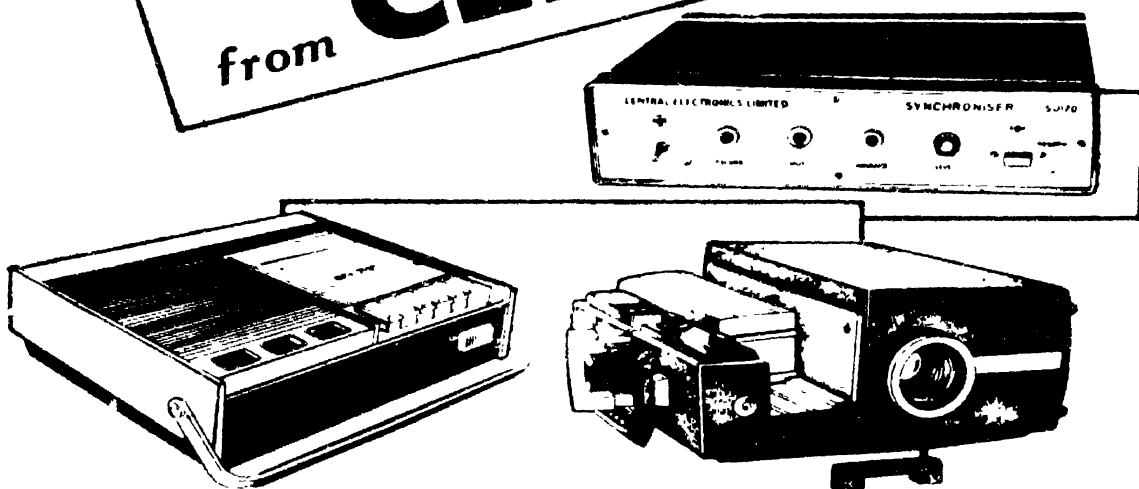
- Hill Publishing Co. Ltd.*, 12/4, Asaf Ali Road, 3rd Floor, New Delhi-110002, pp. 184, Rs. 25.50.
3. **SCIENCE OF ENGINEERING MATERIALS Vol. III** by Manas Chanda, *Macmillan Co. of India Ltd.* (address as above), pp. 232, Rs. 15.00.
4. **COMPUTERS, GENESIS, PROGRAMMING AND AP-**

- PLICATIONS** by N. Subramanian, *Wheeler Publishing, A H Wheeler & Co. Pvt. Ltd.*, Eruchshaw Building, 249, Dr. D.N. Road, Bombay-400001, pp. 288, Rs. 36.00
5. **OPERATIONAL AMPLIFIERS** by S.V. Subrahmanyam *Macmillan Co. of India Ltd.* (address as above), pp. 132, Rs. 12.00

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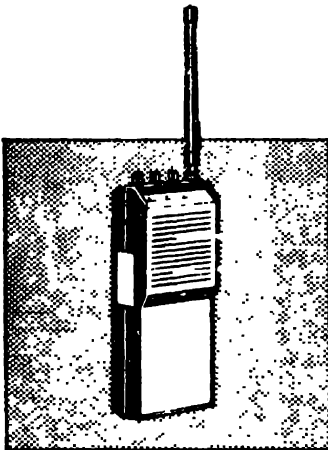
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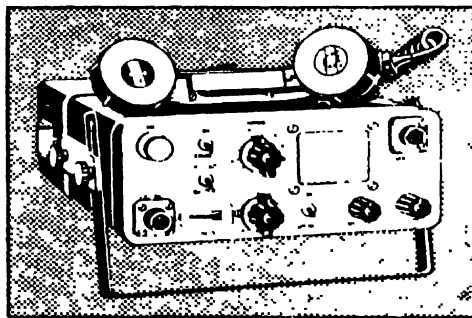
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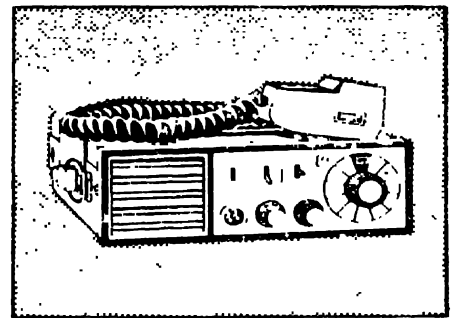
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### Gorilla food for people

Sir, The letter of Alex R. Tindimubona (*S.R.*, February 1980) is most encouraging to all connected with *S.R.* (and to me, especially), for through this medium the observations of an Indian in Zaire has reached a Zairois in Canada. The delightful reminiscences of Tindimubona emphasizing the great gusto with which he enjoyed the juice of "mufumba" (*Rumex abyssinicus*) supports my views on putting this plant to economic use. I, myself also sucked the juice and found it not at all unpleasant and a European lady who partook of it at my suggestion said it resembled rhubarb in taste.

Tindimubona writes that he will be interested to hear of the progress made in this area. I may mention that I tried to detect the presence of emodin in a piece of mufumba tuber I brought with me. Shibata's method of paper chromatography of anthraquinones was tried. Nothing definite has been established about them. Fresh samples may be tried if I could collect some more.

R. L. BRAHMACHARY  
Indian Statistical Institute  
203, Barrackpore Trunk Road  
Calcutta-700035

### Science against superstition

Sir, Though the article under reference (*S.R.*, January 1980) does not adequately deal with all the aspects of the subject, the authors have given

a couple of good books in the reference. In our daily life superstition stares us in the eye and deflects our attention from the primary cause and drives us to a defeatist attitude. The Superstitious sentiments not only make the gullible among us susceptible to financial exploitation, but also lead us to perpetrate some gruesome practices like animal and human sacrifices.

Nowadays we see articles flooding the news-world describing dubious sciences like psychokinesis (mind's vital force over the matter), dianetics, bycanthropy, mediumistic trances, etc., Literature on occultism has become the 'in' thing with our magazine world, to a large extent.

It makes us sick that some scientists themselves are utterly superstitious. We have got a clan of pseudo-scientists amidst us who belabour their beans to find some scientific basis for superstitions. Tromb comes to the rescue of astrology arguing that stars influence earth's electromagnetic fields. Some physicists still raise their eyebrows at Uri Geller in wonder and try to create a scientific fulcrum to all his gimmicks. Aldous Huxley, H.G. Wells, Arthur Koestler, to name but few, advance their own reasons in support of ESP. A few months back, I happened to see an article in *The Sunday Standard*, wherein the author wonders why people resort to complicated and costly modern techniques to detect underground water when the cheap method of using divining sticks is there at our disposal! The so-called scientific attempts to lift the falling Skylab by our ESP men and the results are only too well-known. We also see attempts from certain learned quarters to interpret and explain away the peculiarities of our mythological fables and incidents from our epic lore in the light of modern scientific information and knowledge. David Starr Jordan, the first President of Stanford, in his delightful book "The Higher Foolishness" coins a word,

"Sciosophy", meaning "Shadow Wisdom" which the pseudo-scientists seem to possess. I advise readers to go through another interesting book *In The Name of Science* by Martin Gardner.

K.S.N. KRISHNA  
Lecturer in Botany  
Government College  
Alamuru-533233, E.G. Dt. (A.P.)

### Viewing the eclipse

Sir, I am a regular reader of *S.R.* and am thankful to the journal for publishing interesting articles regarding solar eclipse (*S.R.*, December 1979 and January 1980).

On 16th February, 1980 I observed the total solar eclipse with a simple telescope made by me (Fig 1).

I could find no difference till 14 hrs. 21 mts. in the solar image. Thereafter, the lunar shadow began to cover the sun from lower right quadrant gradually. At 15 hrs. 35 mts. shadow covered 95% of the sun. And at last the long awaited exciting moment came at 15 hrs. 38 minutes. I saw the necklace, i.e., the dark disk-like moon with sparkling light surrounding it. Next moment I saw the diamond ring at 15 hrs. 38 mts. 50 sec. at upper right quadrant. The rarest opportunity came at 15 hrs. 39 mts. which lasted for 2 mts. and a few seconds. The dark shadow of moon was visible with the pearl blue corona of the sun. Twinkling Venus was visible exactly over the head and Mercury between Venus and the sun. At the end of the totality, the diamond ring was again visible at the lower right quadrant of the sun. The shadow waves crept before and after totality. Full image of the sun was visible at 16 hrs. 53 mts.

I observed the eclipse with telescope except at the time of totality and diamond ring phenomenon. The home pets, dog and cat were normal

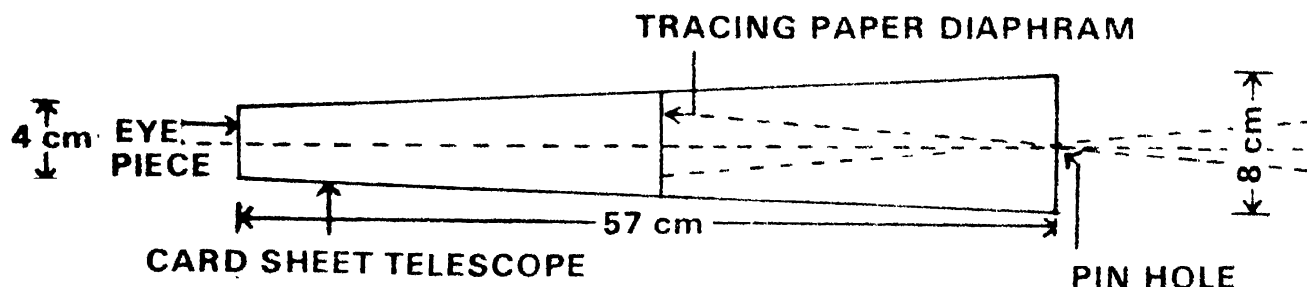


Fig. 1

except they were lazy and lying on the ground, whereas the birds were disturbed on sudden darkness.

As I am not in the field of astronomy, I am unable to cast the report in detail. It will be a boon to the readers like me, if S.R. can collect data and publish a detailed report and findings of this famous solar eclipse.

H.B. DESHPANDE  
47/2, Kulkarnigalli  
Yallapur Lane  
Hubli 20, Dt. Dharwad  
Karnataka

#### The effect of solar eclipse on bees

Sir, I am a bee-keeper and have twelve hives of my own. Being a regular member of Gobardanga Renaissance Institute, I have been experimenting different things on bees for the last three years and I was prepared to observe the solar effect on them during the solar eclipse on 16th February, 1980.

And for that I placed myself near the hives and observed that the bees of the three hives completed their 'play flight' an hour before the scheduled time. Play flight means the introductory play of the bees. This time, nurse bees come out of the hive and confront their outer environment. Every colony has some speciality and so the time of the play flight may vary from colony to colony. In my hives it generally occurs between 2.30 p.m. and 3.30 p.m. But on that day, they took their play flight between 1 p.m. and

2 p.m., that is much earlier than usual.

The eclipse began at 2.47 p.m. and then darkness came down on the earth slowly. I observed, the bees were then coming out and going in. Gradually, the shadow of evening came. Thinking that darkness would appear quickly, I had given artificial food for the bees in a weak hive. I saw with great surprise that the bees had begun to consume the given food. I saw a group of bees on the bee-entrance with pollen grains. It was 3.57 p.m., when the darkness was deep. I observed a great number of bees were entering the hives as they generally do in the evening time.

After the full eclipse, when the sun began to come out of the shadow, the bees began to come out of their hives again.

Solar eclipse may or may not have any physical effect on them. But it was observed that the queen bees did not stop their hatching, even at the time of the eclipse.

On the 17th February, 1980, it was observed that the temperament of the bees was not normal, they were rather ferocious that day.

SWAPAN CHAKRABORTY  
Gobardanga Renaissance Institute  
P.O. Khantura  
Dist. 24-Parganas (W.B.) 743273

#### Makardhwaj

Sir, I would like to draw attention of the pharmaceutical and drug manu-

facturing community in the country on the use of *Makardhwaj* in Ayurvedic system of medicine. It is known that all compounds of mercury are cumulative poisons and therefore the continued use of mercury compounds by the Ayurvedic physicians appears to be an anomaly. I would like to have the opinion of biochemists, ayurvedic physicians and pharmacists in this respect.

VED PRAKASH  
Asst. Director  
National Metallurgical Laboratory  
Jamshedpur-831007

#### Automobiles and air pollution

Sir, With reference to the article **Automobiles and air pollution** by B. Haragopala Rao (S.R., December 1979), I would like to add a few points from W.H.O Technical Report Series No. 410 of 1969. Carbon monoxide peaks of 100 ppm have been recorded at street level at important intersections in the Indian metropolitan cities, and it is almost six times more than that of Chicago (U.S.A.). The reason for such a high concentration of automobile pollution in India is that many of our vehicles have a high weight-to-horse power ratio and they are often old and poorly maintained. The horse power of 85% of the cars in India is between 10 and 14, and 60% of vehicles are more than ten years old. Also maintenance is poor because spare parts are expensive and technical competence is low. Consequently automobile pollution in India is out of all proportion to the number of

cars in circulation.

V. SRINIVASAN

Department of Physiology  
Jawaharlal Institute of Post  
Graduate Medical Education &  
Research, Pondicherry-605006

### Superphone speakers

Sir, N.L. Pathak, S.K. Agarwal and Hemmadi (S.R., Jan., 1980) have given a very interesting and informative review of the various types of microphones, including the latest one, electret microphone. Recently, I came across one German made stereo tape-recorder having electret microphones and superphone speakers. I found sound clarity of the superphone speakers was better than that of two way-speakers (Woofer & Tweeter). Would you enlighten us about superphone speakers in your ensuing issues?

S. G. K. MURTHY  
State Bank of India  
Industrial Estate Post  
Vijayavada-520007 (A.P.)

### Grey hair

Sir, I have read **Greying of hair** by L. K. Vasistha (S.R., Feb. 1980) and would like to make following comments :

(a) Hypothyroidism, and not hyperthyroidism, is one of the causes of grey hair; and (b) Besides, there are other common causes, i.e., use of chemicals on the hair in the form of medicated oils, congenital albinism hypopituitarism, etc., which have not been mentioned.

B. M. DAS ADHIKARY  
Post-Graduate Training  
& Research in Ayurveda  
294/3/1, A.P.C. Road  
Calcutta-700009

### Azospirillum

Sir, Thanks for publishing the article **Azospirillum—a new bacterial fertiliser for tropical crops** by N. S. Subba Rao *et al.* (S.R., October 1979). The author has given a very good account of *A. brasilense* as a bacteria fertilizer. In this context, I would like to add that besides *A. brasilense*, there is another species *A. lipoferum* which helps a lot in the nitrogen economy of crop plants. It has been isolated from most of the weed plants associated with rice in an aquatic ecosystem.

*A. lipoferum* shows variations in nitrogen-fixing efficiency depending upon the source. Nitrogen-fixation is higher in cultures isolated from the roots of *Pistia stratiotes*, *Marsilea quadrifolia*, *Euphorbia hirta* and *Boerhaavia rapens*. Lower rates of  $N_2$  fixation have been observed in *Lucus aspera*, *Colocasia anticonium* and *Cyperus* species.

M. K. RAI  
Deptt. of Biological Sciences  
University of Jabalpur  
Jabalpur-482001

### Immobilised enzymes

Sir, We read with interest the article **Immobilised enzymes—an aid to food industry** (S.R., Dec. 1979). It was interesting, informative and well illustrated. But the article has not mentioned anything about enzymes isolated from Thermophiles (organism growing at elevated temperatures) which are being studied as a tool in enzyme engineering. These enzymes are heat-stable and can be handled at elevated temperatures without loss

of activity, whereas the conventional enzymes can be handled only at low temperatures ( $4^\circ\text{C}$ ), otherwise they get inactivated. Several thermo-stable enzymes of industrial application have been studied and are under investigation in laboratories.

MIR NASSER HUSSAIN  
MALIK ASGHER  
Madras-600014

### 'Water-in-oil' type emulsion

Sir, In the write-up **Cold cream** by S. Bhanumati and S. Narayan (S.R., December 1979) on page 859, second column, second para line 5th, it is stated that cold cream is an "oil-in-water" type of emulsion, whereas it is "water-in-oil" type emulsion. The main difference between the two is that in the former (o/w type) oil forms the dispersed phase and water the dispersion medium. Other examples of this type are milk, vanishing cream, etc. In the latter (w/o type), water forms the dispersed phase and oil the dispersion medium; for example, butter, cold cream, etc.

SANJAY KUMAR HAJELA  
Deptt. of Chemistry  
L. R. College, Sahibabad  
Distt. Ghaziabad (U.P.)

### Industrial electroplating

Sir, I request you to publish an article on "Industrial electroplating" of various metals. It will acquaint us with instruments, equipments and electrolytes used in industry.

A. K. CHAUDHURI  
Howrah-711109

# Planets and their positions

July 1980

## The planets

**Mercury (Budha)** is too near the sun to be visible during the first three quarters of the month. It is in inferior conjunction with the sun on 12th. Thereafter it reappears as a morning star and rises about one and a half hours before sunrise. It passes about  $10^\circ$  south of the star Pollux (*Punarvasu*) on the 2nd. It becomes direct on 22nd. It moves from Cancer (*Karkata*) to Gemini (*Mithuna*) by retrograde motion. Its visual magnitude varies from  $+1.9$  to  $+0.5$ .

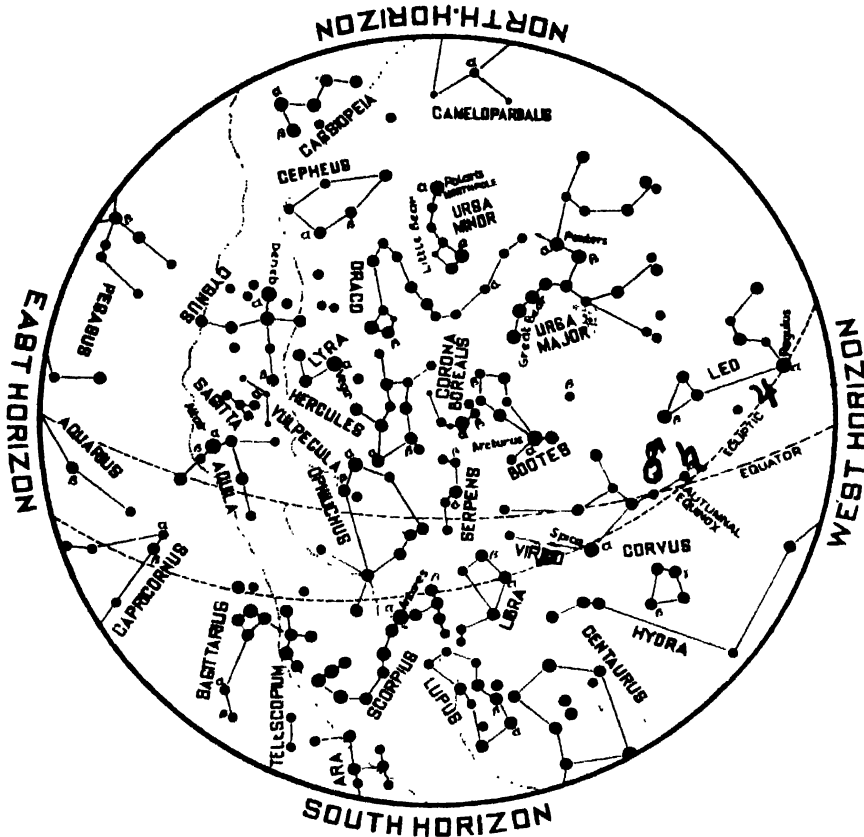
**Venus (Sukra)**, a morning star visible in the eastern sky, rises about two hours before sun rise during the first half of the month and about three hours before it during the second half. It becomes direct on 7th. It attains the greatest brilliancy on 22nd. It moves from Taurus (*Vrishha*) to Gemini (*Mithuna*). Its visual magnitude is about  $-4.2$ .

**Mars (Mangala)** visible in the evening sky on the western horizon, sets about one and a half hours before local midnight during the first half of the month and about two and a half hours before it during the second half. It is in Virgo (*Kanya*). Its visual magnitude is about  $+1.3$ .

**Jupiter (Brihaspati)**, visible in the evening sky on the western horizon, sets about three hours after sunset during the first half of the month and about two hours after it during the second half. It is in Leo (*Simha*). Its visual magnitude is about  $-1.3$ .

**Saturn (Sani)**, visible in the evening sky, sets about one and a half hours before local midnight during the first half of the month and about two and a half hours before it during the second half. It moves from Leo (*Simha*) to Virgo (*Kanya*). Its visual magnitude is about  $+1.4$ .

(Source : Director, Positional Astronomy Centre, India Meteorological Deptt. P-546, Block 'N' (1st Floor) New Alipore, Calcutta-700053).



♂ MARS  
♃ JUPITER  
♄ SATURN

The moon

MAGNITUDES  
-1 0 1 2 3 4 5  
◆ ● ● ● ● ● ●

**N**EW moon occurs on 12th at 12.16 p.m. and full moon on 28th at 0.24 a.m. I.S.T. The moon passes very close to Venus on 10th, about two degrees north of Mercury on 12th, half a degree north of Jupiter on 16th about a degree north of Saturn on 17th and three and a half degrees north of Mars on 18th.

The lunar crescent becomes first visible after the new moon day in the evening of 13th.

The moon is at perigee or nearest to the earth on 4th and again on 31st and at apogee or farthest from it on 19th.

The earth is at aphelion or farthest from the sun on 5th.

**A**NY structure in the world is a three dimensional structure, i.e., a space structure. These structures consist of two dimensional elements like beams, girders, portal frames and arches, and are interconnected in the third dimension to achieve stability. All these structures are assumed as two dimensional for analytical purposes, since the analysis of these structures in the three dimensional form is complicated. Also, in many structures like multi-storeyed frames and roof trusses, the inter-connecting members in the third dimension are merely provided for the purpose of transversing load and not sharing the load.

The advent of computers makes it possible to analyse any complicated form of construction and many space structures have been evolved in the recent years to share loads in three dimensions. This three dimensional

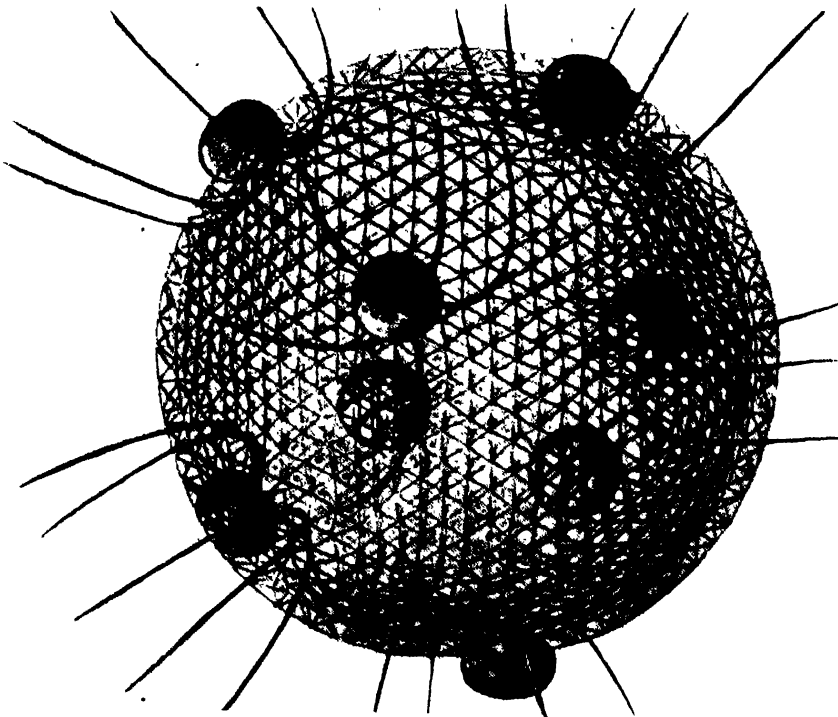
load sharing is very important with regard to the economical considerations.

A space structure may be defined as a three dimensional assembly of elements designed to function in three dimensions or as a three dimensional assembly of elements resisting the loads which are applied at any point, inclined at any angle to

# WHY NOT SPACE STRUCTURES?

N. SUBRAMANIAN

**Besides being architecturally sound, space structures can be built from simple, prefabricated units by semi-skilled labour**



**Fig. 1. Three dimensional multilayered arrangement of struts in Radiolaria**

the surface of the structure and acting in any direction.

## History of space structures

Like any other element of structural engineering, the history of space structures is also very interesting. Like the shell structures, whose form has been derived from the egg, the space structures having interconnecting, modular, identical units have also been derived from the skeletons of certain sea-structures occurring in nature.

R. Le Ricolais, of the University of Michigan, U.S.A., carried out detailed studies on skeleton configuration in certain natural forms and in 1940 drew attention to the geodesic type of spherical surfaces found in the skeleton structures of sea fauna, various radiolaria and algae. The perfect three dimensional multi-layered arrangement of struts in the skeleton formation of



Radiolaria (*Tuscaretta globosa*) (see Fig. 1) has been successfully used in the geodesic domes.

Alexandar Graham Bell, the inventor of telephone, concerned himself with space structures based on tetrahedron. He developed space frames having combinations of axially loaded members. Fig. 2 shows a three-way space frame constructed by him using metal rods and connectors in 1907. He also mass produced prefabricated standardized units.

#### Advantages of space structures

The remarkable popularity of space structures all over the world is due to a number of factors. The most important ones are listed below:

1. Shortage of qualified labour has put an increasing importance on prefabricated and industrialized form of construction. Space structures can be built up from simple, prefabricated units, which often are of standard size and shape. Such units, mass produced in the factory, can be easily and rapidly assembled at site using semi-skilled labour. The small size of components greatly simplify the handling, transportation and erection.

2. Large unobstructed areas (column-free areas) are required for industrial buildings, sports stadia, assembly rooms, swimming pools, exhibition halls and theatres. Space structures are ideally suited and provide unique answer to these requirements. They are very economical for large spans.

3. These structures are architecturally impressive and have aesthetic beauty.

4. They have built-in reserve strength which makes them resistant to local overloading, fire resistant, blast resistant and earthquake resistant. They allow great flexibility in layout and positioning of columns. Some columns may even be removed without damaging the structural integrity of the framework.

5. Many special types of connector are available, and using these even complex space structures can be assembled by semi-skilled labour.

6. They provide uniform stress distribution even under unsymmetrical loading.

7. They allow the use of non-structural materials like aluminium and plastics.

8. They eliminate the use of complicated and expensive framework.

9. Lights, airconditioning ducts and other service facilities can be kept inside the roof elements, and

10. Space structures are demountable.

#### Types of space structure

Space structures are usually classified into three main groups, viz., skeletal structures, stressed skin structures and suspended structures.

Braced domes, barrel vaults, single, double and multi-layer grids and

frame folded plates are examples of skeletal type. Folded plates belong to stressed skin system and cable roofs to the suspended types.

It is very difficult to discuss about all these types in an article of this nature. Moreover, stressed skin systems and suspended systems have yet to gain their popularity in many countries due to their connection difficulties. Hence, only the popular skeletal systems are discussed.

#### Braced domes

Domes are the oldest structural forms used by man (Eskimos use domes for their houses). They enclose a maximum amount of space with a minimum surface and provide one of the most efficient structural shapes permitting the covering of very large areas in an economical way. The earliest example of a dome is reported as one belonging to the 14th Century B.C. The development of domes is

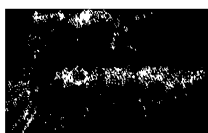


Fig. 2. Three-way space frame constructed by Graham Bell

Table 1. Dead weights of domes

Sl. No.	Description	Diameter m	Total weight tons	Unit weight kg/m <sup>2</sup>
1.	Pantheon dome, Rome, built in 120-124	44	11,000	7,200
2.	Reinforced concrete ribbed dome, Worclaw, built in 1925	65	6,340	1,920
3.	Reinforced concrete shell over Octagonal ribbed vault, Leipzig, 1947	69	2,200	383
4.	Houston steel dome, U.S.A.	200	2,150	80

closely associated with the development of available materials. In the past, domes have been built in stone, timber, masonry and reinforced concrete. The necessity for complicated formwork to support the concrete shells during the casting periods makes concrete domes rather costly. Hence, recent developments are connected with braced domes.

Braced domes are composed either of members lying on a surface of revolution or of straight members with their connecting points lying on such a surface—an arrangement which avoids any obstruction of the inner space.

Domes are sub-divided into : (1) Frame or skeleton type, (2) Truss type or double layer type, (3) Stressed skin type, and (4) Formed surface type. The classification of braced domes, according to the pattern of bracing adopted, is extremely difficult to explain since great variety of possible types of bracings are available. Fig. 3 shows the five most popular types frequently used.

Many interesting examples of each of these types of domes are existing in France, Japan, U.K., U.S.A., Russia, Italy and in many other parts of the world, the most impressive example of dome being the geodesic dome built by Buckminster Fuller and his associates for the United States pavilion at Expo '67.

Table 1 shows clearly that the developments of new material and improved technology help reduce the dead weight and at the same time increase the clear span of the structure.

### Barrel vaults

A braced barrel vault is a structure similar in configuration to a shell; it is, however, not homogenous, being an assembly of bars. Often, a braced barrel vault consists of several lattice trusses, which span the length of the barrel and are supported on end trusses or walls. All these lattice girders are interconnected by common

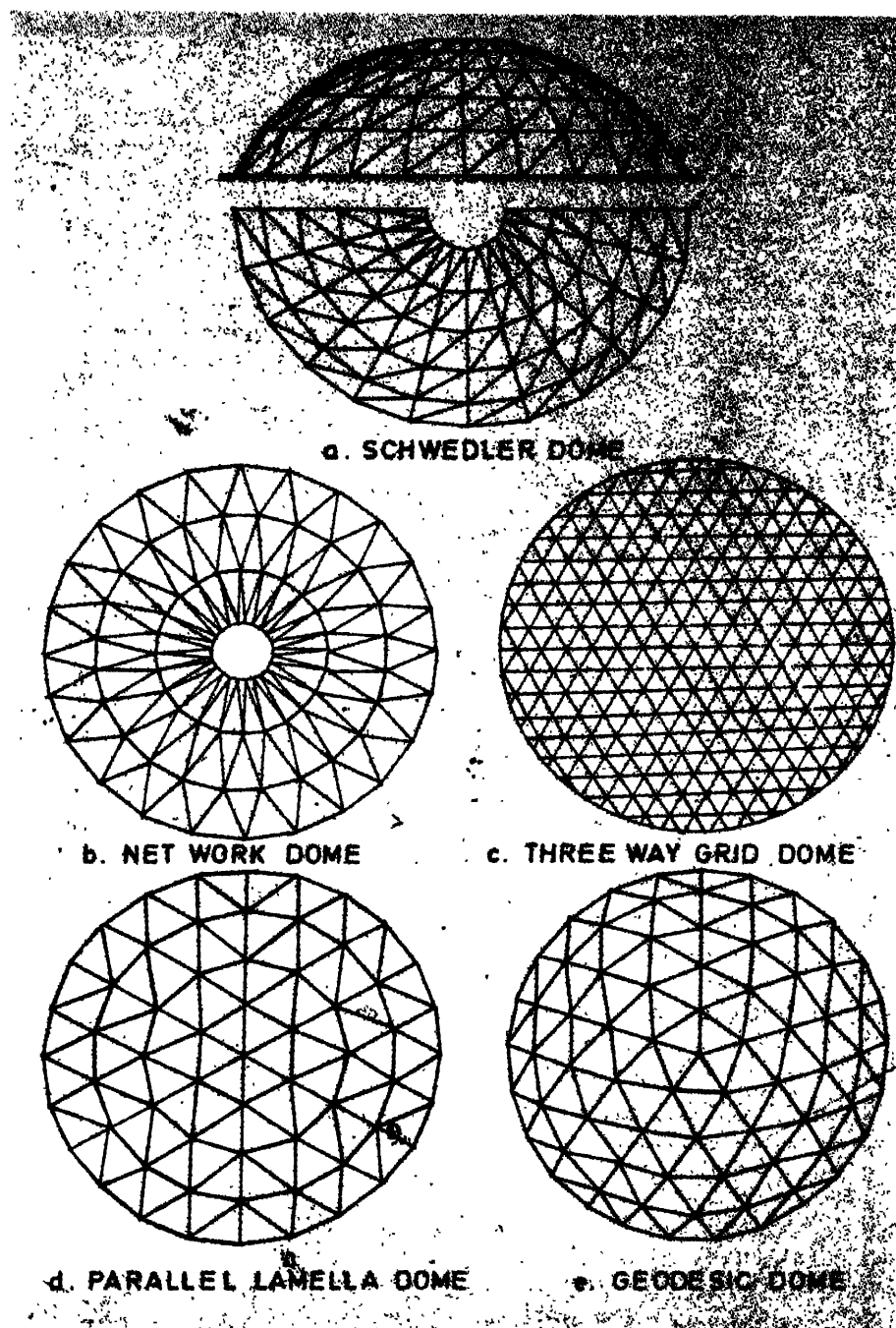


Fig. 3. Different types of braced domes

booms forming a three dimensional system.

Braced barrel vaults are often used to cover industrial buildings, swimming pools, tennis courts, etc. Fig.4 shows the six principal types of bracing systems used. Computer analysis and actual tests show that the three way grid type of bracing (Fig. 4c) provides

uniform stress distribution, and because of its inherent rigidity, this type is frequently used.

Many structures of this type have been built from simple, prefabricated units in steel, aluminium, timber and concrete. Typical examples of such structures are the winter sports stadium in Kladno (60m x 60m) and the sports

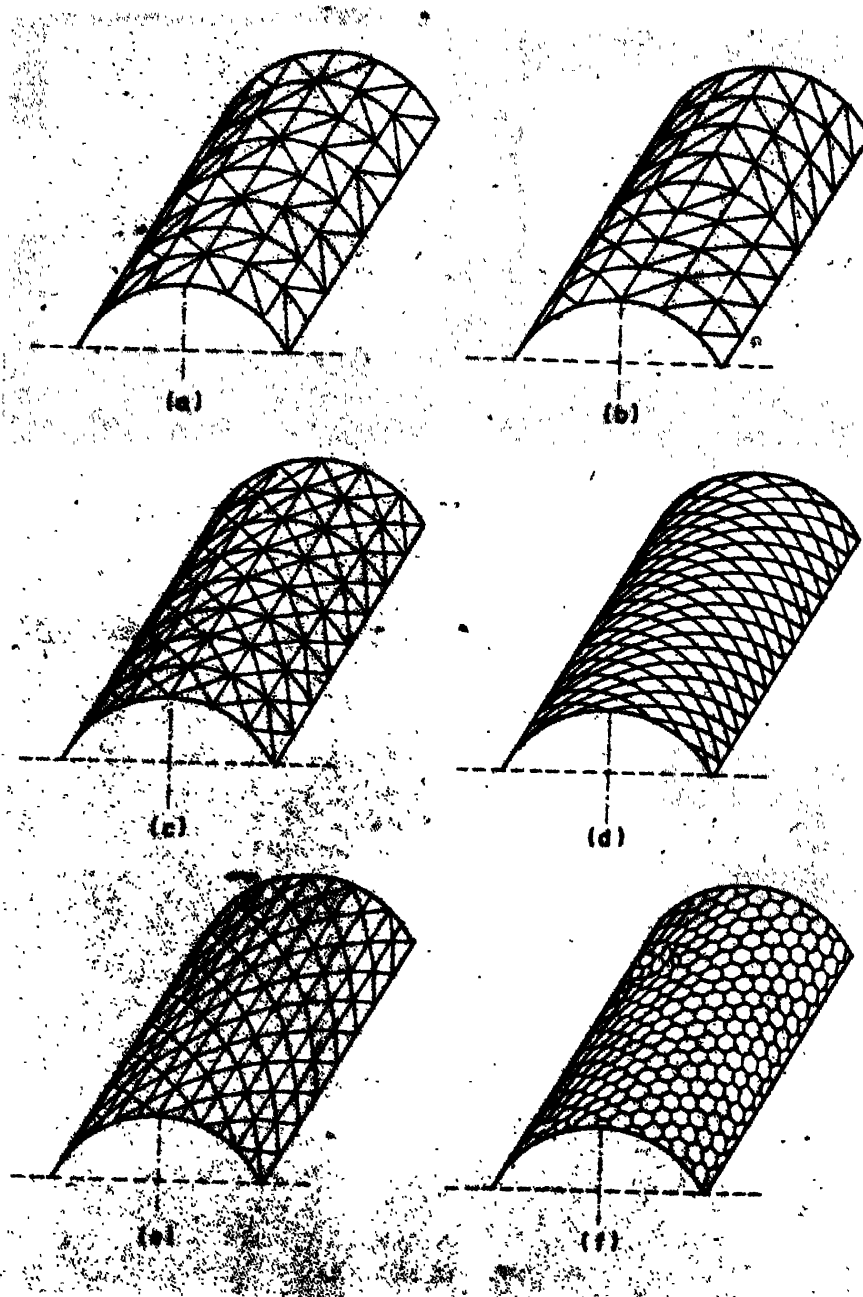


Fig. 4. Different types of braced barrel vaults

hall in East Berlin (59 m  $\times$  75 m). The dead weight of the Kladno barrel vault is only 18 kg/m<sup>2</sup>.

The cost of braced barrel vaults will be considerably less than reinforced concrete shells, mainly because the braced framework is self-supporting and does not require any scaffolding during erection.

#### Grids

Grids are ideally suited for structures which may be under the action of heavy concentrated loads. Double layer grids consist of two plane grids forming top and bottom layers, parallel to each other, and interconnected by diagonal members. Fig. 5 shows six main types of double

layer grids used by various firms all over the world. Basically, there are two main types of double layer grids—lattice or truss grids, consisting of intersecting vertical lattice girders and true space grids consisting of a combination of tetrahedra, octahedra or skeleton pyramids having square or hexagonal bases.

From structural point of view, the true space grids are superior to lattice grids because of their greater rigidity. On the other hand, however, the transport and erection of lattice grids are simpler since they consist of flat lattice trusses which can be stored and transported very easily. The flat space grids can provide a column-free roof system with a depth/span ratio of about 1:20 to 1:25 and are economical for spans of length over 90 m.

Many such grids have been constructed all over the world (except India), and most recent examples are the exhibition halls in Dusseldorf, West Germany, where over 100,000 sq.m. are covered by double layer grids. These exhibition halls are each 30 m  $\times$  30m resting at 4 corner points only! Fig. 6 shows the construction of a factory in Southern England using double layer grids.

The world's largest two-way, two-layer rectangular steel space grid forms the roof of the Osaka Expo 1968 building in Japan. This roof measures 292 m  $\times$  108 m and is 30 m high. It weighs 4800 tonnes and was jacked up into position from ground level. Triple and multi-layer grids are extensions of double layer grids and can be used to cover still larger spans.

#### Folded plate roofs

The beauty and elegance of the forms obtainable in reinforced concrete shells attracted the attention of engineers and architects to this material. These systems can be built using precast reinforced concrete, plywood, plastics, aluminium and steel.

These systems derive most of their strength from their shape—their

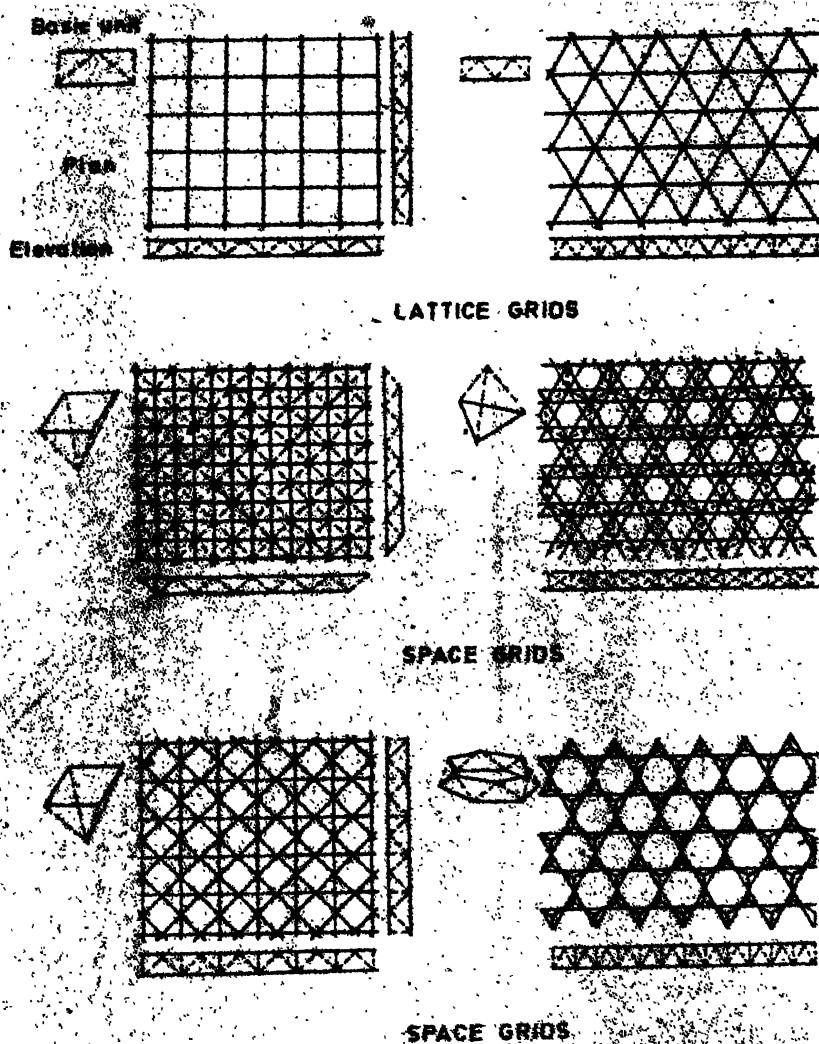


Fig. 5. Different types of double layer grids

tures was often offset by difficulty of analysing such highly indeterminate systems. The advent of computers and the use of matrix methods have made the analysis of such structures very easy which otherwise looked impossible. Many readymade computer programs are available for the analysis of such structures. The author has developed a series of computer programs for different analyses of such structures.

Many approximate methods are also available for the preliminary design of space structures.

#### Construction of space frames

Another difficulty which prevented the extensive construction of space structures is the difficulty of joining together several members in space at different angles. But, till now, more than 100 patented connectors have been developed. A few connectors are extensively used all over the world and they include: 1. Merosystem, 2. Space deck system, 3. Unistrut system, 4. Oktaplatte system, 5. Nodus system, 6. Unibat system, and 7. Triodetic system.

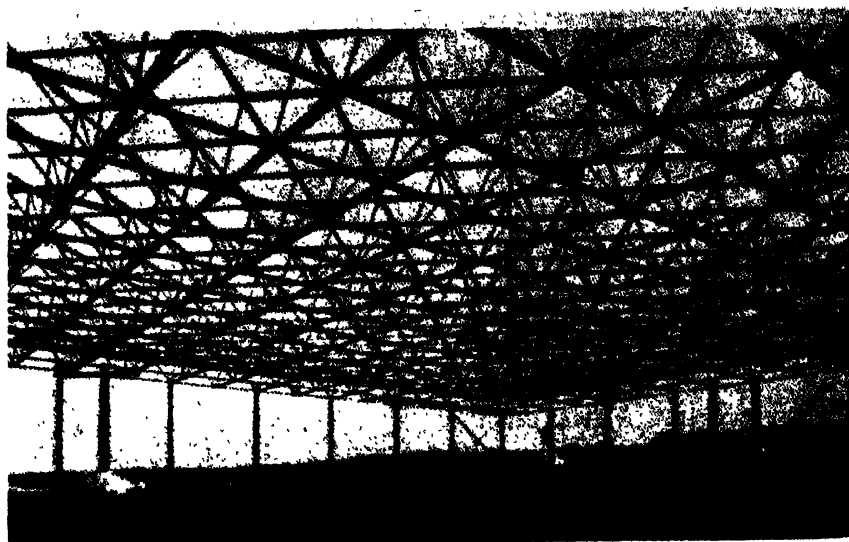
form gives them great rigidity making possible efficient use of construction materials of low Young's modulus, such as plastics and aluminium, which in the orthodox type of construction would normally lead to excessive deflection.

Interesting types of structures have been built in many parts of the world. One such is the roof over the SISI Building, Bangalore.

#### Analysis of space structures

The construction of space struc-

Fig. 6. Factory roof in England using double layer grids



Under a project, sponsored by the C.S.I.R., the author has developed a prefabrication system (using open web joists) for the construction of steel frame folded plate roofs.

### Transportation and erection

Transportation of these structures is easy. The single elements can be joined to form open braced triangles or pyramids or tetrahedrons and can be nested for transportation. Hence, space required for storing and transportation is reduced considerably.

The methods of erection of space structures are similar to that of other steel structures. Three special methods are also used, viz., lift slab method, cantilever method and a combination of the two. In the lift slab method, the frames are assembled at site and lifted by cranes to fix it in its final position. In the cantilever method,

the operation starts from one support. With the use of temporary scaffoldings, the whole structure is built at the roof level.

### conclusions

The savings resulting from the use of space structures can be as high as 30 per cent. The author has found that the folded plate construction can be used economically for even smaller spans. The space frame concept has also been recommended in many countries for mass housing projects and for multistorey building construction. J.F. Gabriel, of the Syracuse University, U.S.A. has proposed many interesting projects for housing using multi-layer space frame constructions which can accommodate more than 40 houses. To the author's knowledge only a few domes exist in India. It is hoped that the potentials of space structures will be felt very soon in India. Com-

bined with creative thinking many more projects can be developed using space structures to house thousands of people in India economically.

### Further reading

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4. Subramanian, N. and Ganapathy Chettiar, C., A Space frame roof for industrial buildings, *The Bridge and Structural Engineer*, December 1977, pp. 39-59.
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6. Benjamin, B.S., *The Analysis of Braced Domes*, Asia Publishing House, Bombay, 1963.

## Answers

### Science quiz

- (1) a, (2) b, (3) c, (4) a, (5) b, (6) b, (7) c, (8) b, (9) c, (10) c.

### Brain teasers

1. See Fig. 3.
2. Saw the board along AF and FG. This will require two sawings. Reassemble the pieces as shown in Fig. 4. By simple geometry it can be proved that the areas ABF and GCF are respectively equal to the areas EDH and DGH.
3. Kamal Kishore is a lawyer while Kalp Nath is an engineer leaving Krishna Kant who must therefore be a doctor. So, Nargis will marry the doctor. Now, as Namita is not engaged to the engineer, she must

marry Kamal Kishore, the lawyer. Niharika's husband will then be Kalp Nath who is the engineer.

4. By drawing just one coin from any box, the contents of all the three boxes can be known. Suppose that you have taken a gold coin from the box labelled SG (i.e., silver-gold). As the label on this box is ought to be incorrect, the other coin in the box cannot be silver; hence it should be gold. Thus you are able to identify the box containing two gold coins. You can now at once tell the contents of the box marked, say, SS. This box cannot contain two silver coins because its label has to be wrong. Nor can it contain two gold coins for you have identified that box. Therefore, it must contain one silver and one gold coin.

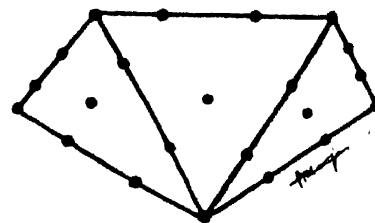


Fig. 3

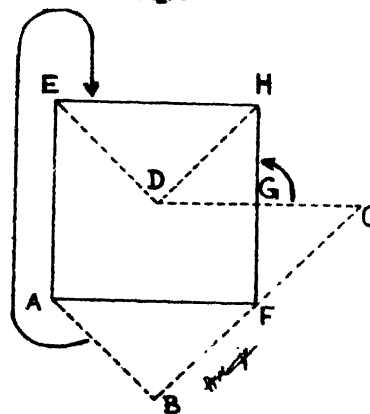


Fig. 4

The remaining box must then obviously hold two silver coins.

**I**N our childhood, most of us have heard the amazing stories from our grandmothers how *Rahu* devours sun and moon causing eclipses and how our earth, which is like a disc, rests on the hood of the serpent *Basuki*. Almost all the ancient civilizations had such crude ideas about earth and the universe. In Babylon, earth was believed to be like a box having a large mountain at its centre from which the river Euphrates flowed. The land is surrounded by seas and beyond them are heavenly mountains, which hold

there is emptiness beyond its boundaries. At the centre, there is a great central fire (Fig. 1) and earth and the other planets revolve round this great fire in circular orbits. In the orbit closest to the fire is a counter earth and in the subsequent orbits come earth, moon, sun and the other planets. In the last orbit is the celestial sphere containing the motionless stars. Earth revolves in such a way that its other side always faces the central fire and hence it cannot be seen from our hemisphere. Earth makes a com-

belief that earth is at the centre of the universe, and secondly attributes a motion to earth. These two revolutionary ideas were later overthrown by the geocentric (in which earth is considered to be at the centre of the universe) models forwarded by Eudoxus, Hipparchus and others.

Pythagoras was also an admirer of music and determined the relations between the lengths of a musical chord and the notes emitted by it. He seems to have held the idea that the intervals between the heavenly bodies were

## HOW LAWS OF PLANETARY MOTION WERE DISCOVERED

**R. BRAHMACHARI**

the sky. In Egypt, earth was believed to be like a shallow pan surrounded by a large river. A boat on this river carried the sun causing day and night.

It took thousands of years to change these primitive ideas and the reasons are two fold. Firstly, all observations had to be performed from a moving earth and, secondly, as a result, the observed movements of the heavenly bodies were not absolute but relative to this moving earth. It was rather impossible for the primitive man to attribute a motion to earth as its movements cannot be felt. So man had to wait to overcome these hurdles by means of keen observation and intelligence.

The oldest scientific model of the universe was presented by the Pythagorean school but this model is usually attributed to Philolaus (475 B.C.). According to this model our universe is finite and spherical in shape and

**What guided the planets in their motion around the sun remained a mystery for centuries till Kepler discovered his famous laws of planetary motion**

plete rotation around the central fire in twentyfour hours causing day and night. The interesting part of the model is that it includes an invisible and opaque counter earth. Pythagorians believed in some mystic powers of numbers and attributed number five to colour, six to cold, seven to health and so on. Perhaps, this belief was imported by Pythagoras himself from China. For, by including the celestial sphere, total number of heavenly bodies becomes nine. Pythagorians were not ready to accept that the creation of God could be of such an incomplete figure nine. They, therefore, made it a sacred number ten by including an imaginary counter earth.

The merits of the model are two fold. Firstly, it ignores the common

determined by the musical harmony. In this context, it would be relevant to mention that the theorem of geometry attributed to him was already known in India and Egypt.

Eudoxus (408-355 B.C.) was a student of Plato's Academy and was a believer of geocentric universe. He imagined large concentric and invisible spheres and thought that each planet is attached to a point on the equatorial circle of these spheres. Further, these spheres rotate about a fixed axis (diameter). All the planets, as a matter of fact, revolve round the sun in an anticlockwise fashion. But as we observe them from the moving earth, their movements are seen to be greatly non-uniform. Sometimes they seem to move very fast, sometimes slow and

sometimes appear to be standing still. Moreover, they are sometimes seen to retrograde ("bakra gati" in Indian astronomy). This non-uniform motion of the planet was a great problem to the astronomers of the geocentric school and Eudoxus tried to explain it by introducing some form of interaction between his imaginary spheres. In certain cases, some idle spheres were also introduced for this purpose. In all he considered 27 spheres and placed the motionless earth at the centre of these spheres.

Aristotle (384-322 B.C.) was an admirer of this model and argued that as fire is lighter it cannot occupy the central position and for that a heavy mass is needed. Furthermore, he thought that there is a celestial intelligence to move these spheres.

If the model of Eudoxus is accepted the distance between a planet and earth should remain constant throughout a year and so also the brightness of planets. But Heracleides (388-315 B.C.) noted a considerable change in brightness in Venus and Mercury. So, he considered two separate orbits for these two planets around the sun and kept all other planets revolving round earth (Fig. 2).

The man who tried to reach the truth with the help of observational data and mathematics avoiding conventional beliefs and ideas was Aristarchus (310-230 B.C.). He was a disciple of Straton and was older than Archimedes by 23 years. He is renowned for his heliocentric (with sun at the centre of the planetary system) model of the planetary system and is known as the Copernicus of the antique. To improve the accuracy of observations he also designed some new instruments.

On the half moon day he found that the angle  $\theta$  between the lines obtained by joining earth and sun (ES) and earth and moon (EM) is  $87^\circ$  as shown in Fig. 3 (actual value is  $89^\circ 50'$ ). Hence

$$\cos \theta = EM/ES \approx 1/19$$

So, he concluded that the distance of

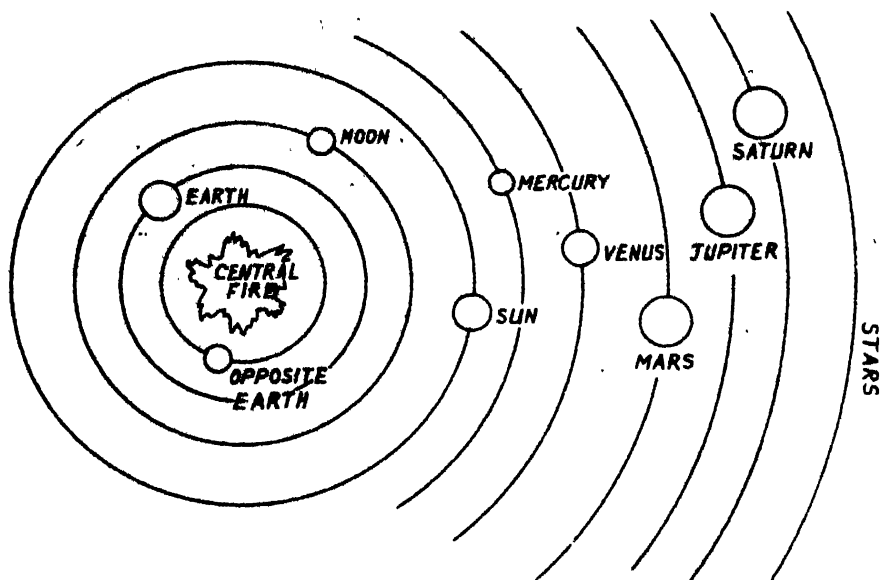


Fig. 1. Universe of the Pythagorean school

sun from earth is approximately 19 times greater than that of moon from earth. He also observed that the angular diameters of sun and moon are nearly equal to  $2^\circ$ . From these two observations he found that the diameter of sun is nearly 6.7 times the diameter of earth and the diameter of earth 2.85 times the diameter of moon. So the volume of sun comes out to be

nearly 300 times that of earth. It appeared to him that sun being so large cannot move round the earth and placed the sun rightly at the centre of the planetary system. In spite of errors in his calculations, he is to be credited for his scientific approach. His conclusions about the universe are as follows:

(1) The radius of the universe is

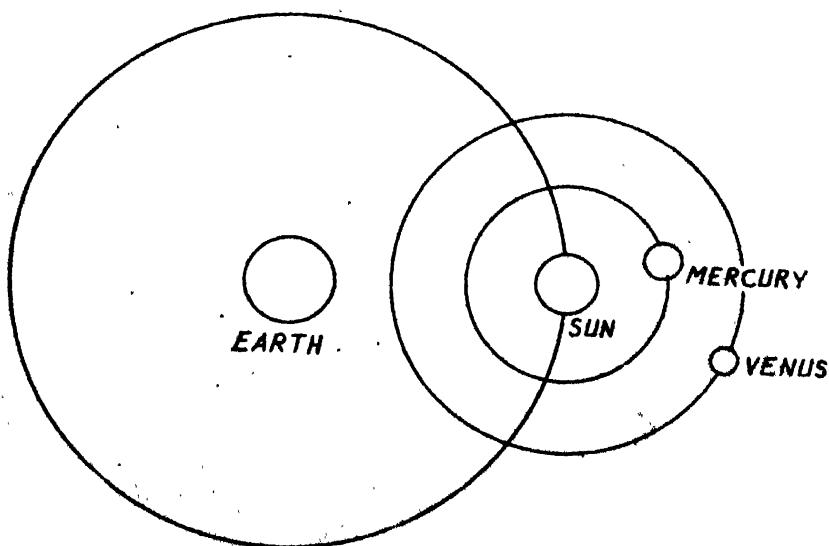


Fig. 2. Orbits of Mercury and Venus according to Heracleides

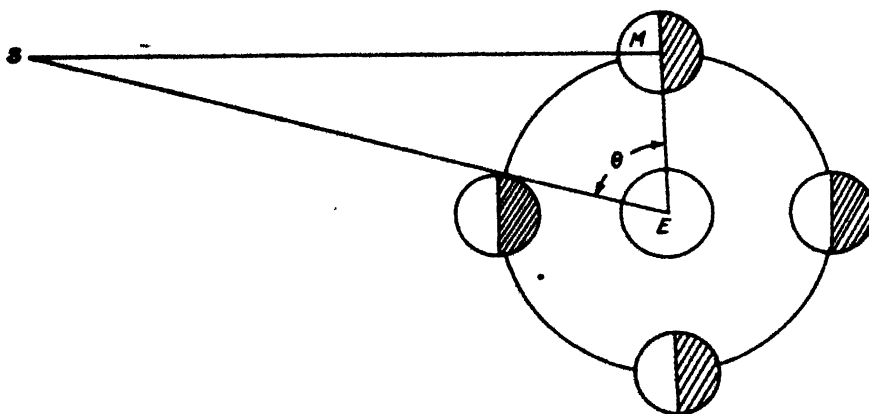


Fig. 3.  $\cos \theta = EM/ES$  1/19

extremely large in comparison to the distance between sun and earth; (2) the sun and stars are motionless; (3) earth and the other planets move round sun in circular orbits; and (4) in comparison to the vastness of the universe, sun and earth are nothing but points.

From the above observational data of Aristarchus it becomes evident that, if by some means the diameter of earth can be measured, the actual diameters of sun and moon and so also their distances from earth can be estimated. This task was done by Eratosthenes (273-192 B.C.). He observed that

at summer solstice, the sun is exactly in the Zenith at Syene (now Aswan) when it is  $7^{\circ} 12'$  south of the Zenith at Alexandria (Fig. 4). So he decided that Alexandria is  $7^{\circ} 12'$  north of Syene on the earth's surface and thus discovered the method of locating a place on the surface of the earth by its latitude and longitude. Furthermore, since  $7^{\circ} 12'$  is equal to  $360^{\circ}/50$  the circumference of earth should be nearly 50 times the distance between Alexandria and Syene. Since Syene is 500 stadia or 800 kilometers south of Alexandria, he found the value of the circumference of the earth to be 2500 stadia

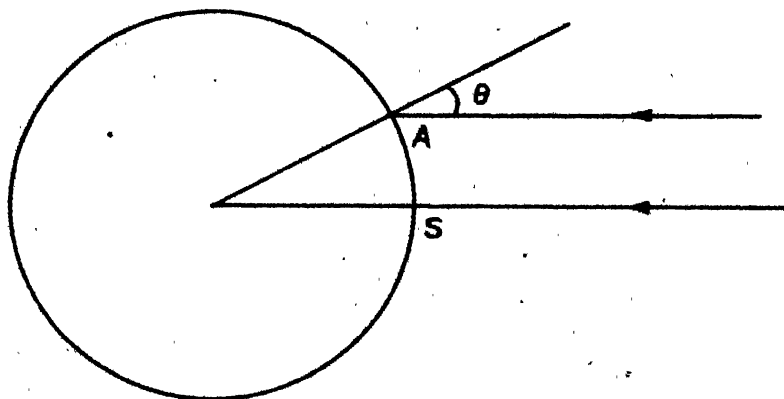


Fig. 4. Position of Alexandria (A) and Syene (S) on the earth's surface is shown (not to scale) at summer solstice ( $\theta = 7^{\circ} 12'$  of arc)

or 40,000 km. (modern value 39,800 km), and hence the diameter of earth to be 12,700 km (modern value 12,640 km). From these data the distance of sun was found to be  $14.72 \times 10^7$  km (modern value  $14.88 \times 10^7$  km).

Eratosthenes also measured the degree of obliquity of the ecliptic with great accuracy. This ecliptic is the path on the celestial sphere which the sun seems to follow during a complete solar year (see *Planets and their positions* on page 363). He also included a leap year and believed in the existence of a vast land (now America) on the other side of the hemisphere.



Galileo

He was the director of the great Public Library of Alexandria, became blind in old age, and committed suicide by voluntary starvation.

Unfortunately, these scientific methods of Aristarchus and Eratosthenes were abandoned later, and the heliocentric conception of the planetary motion was replaced by the geocentric models of Hipparchus (190-127 B.C.) and Ptolemy (?). The chief argument against the heliocentric model was that, if earth is supposed to move round sun, there must be an apparent change in position of the stars, called "parallax", due to the movement of earth. But no such shifts were observed by the then astronomers. Secondly, Aristarchus could not establish his discovery on firm mathematical



grounds whereas Ptolemy, by means of complex geometrical constructions, was able to reduce the discrepancy between theory and observation within the acceptable limits.

Ptolemy was a disciple of Hipparchus who was a firm believer of the geocentric universe. Hipparchus is famous as the discoverer of the fact that the intersecting points of the ecliptic and the equator, called equinoxes, are not fixed but shifts by a very small amount per year. The phenomenon is known as the precession of the equinoxes. But nowadays it is believed that the Hindu astronomers were aware of this fact prior to Hipparchus. Hipparchus also discovered that moon does not revolve round the earth in the same plane in which earth



Kepler

moves round the sun and as a consequence eclipses do not occur every full-moon or new-moon days. He also calculated the length of a solar year within the accuracy of 6.5 minutes.

*Almagest* is the chief work of Ptolemy and this work ruled over the study of astronomy in Europe for nearly 15 centuries. The universe of Ptolemy is geocentric. He explained the irregular, complex motion of planets by two new concepts—deferent and

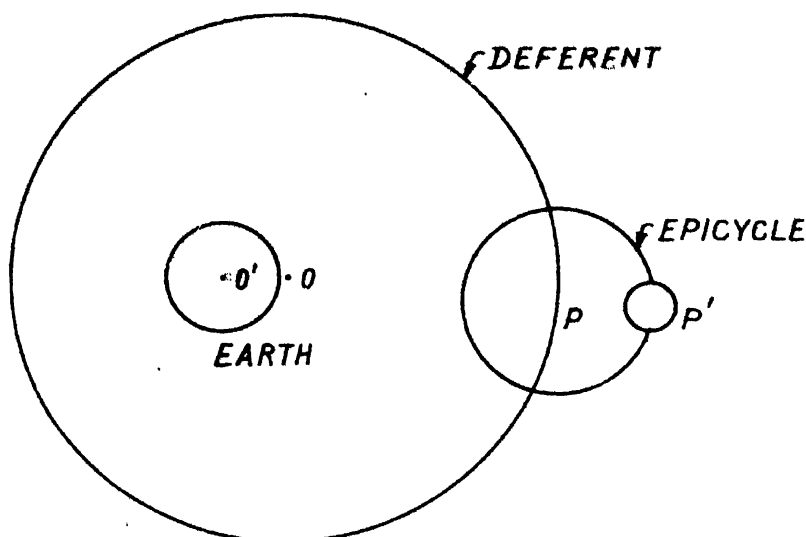


Fig. 5. The centre of the circular orbit is at  $O$  but earth is shifted to the point  $O'$  and the resultant eccentric orbit is called a deferent. The small circle with the centre at  $P$  is called an epicycle and the planet is at  $P'$  on the circumference of the epicycle. The periods of revolution along the deferent and the epicycle are same.

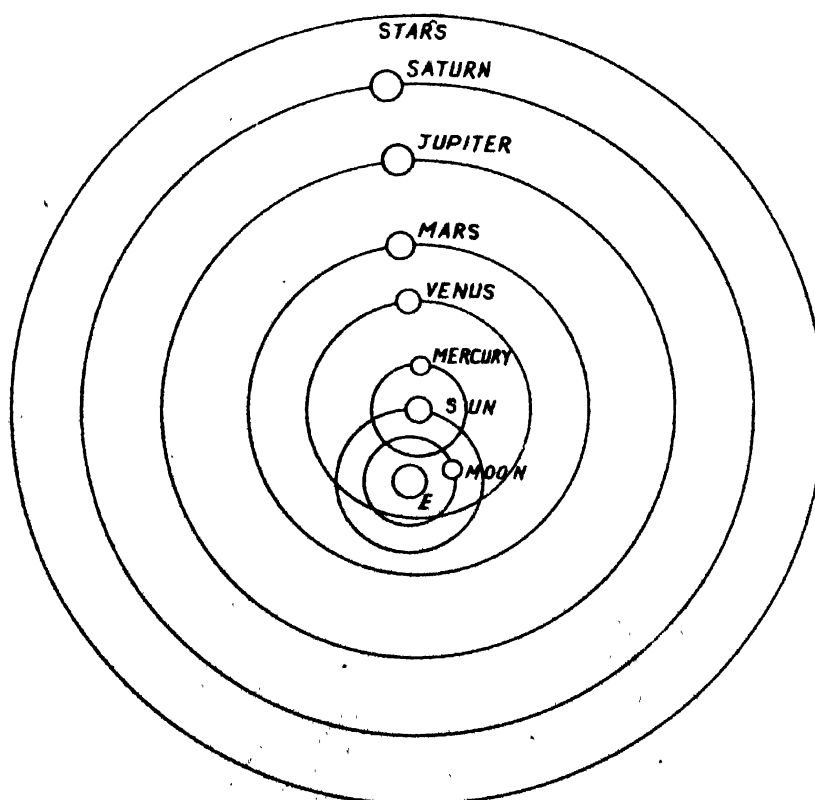


Fig. 6. Solar system of Copernicus (not to scale)

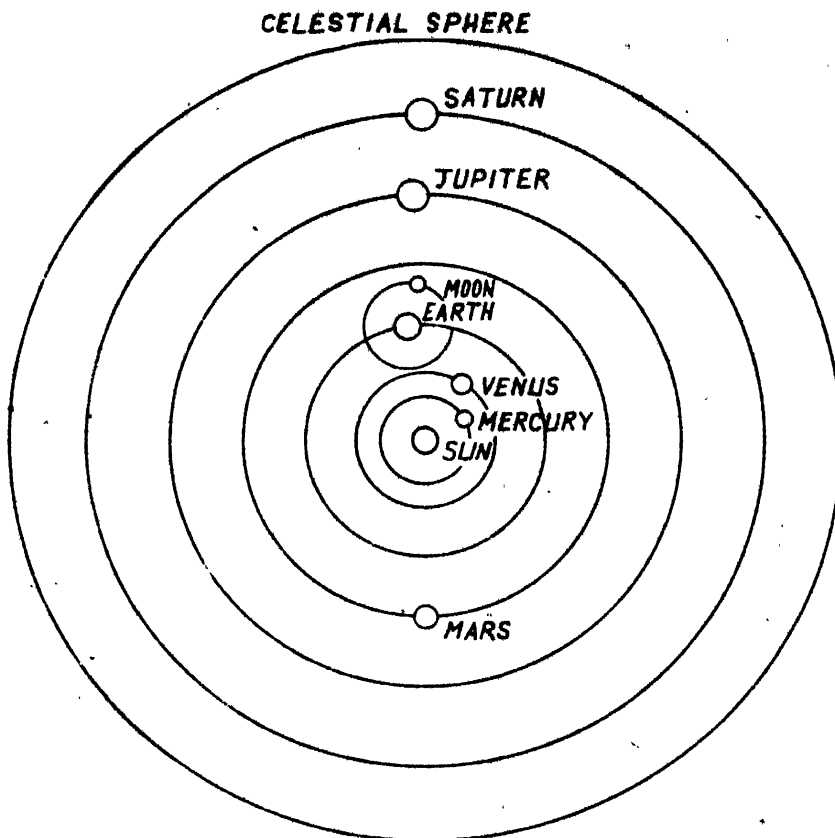


Fig. 7. Solar system of Tycho Brahe. Sun and moon move round the earth which is at the centre of the universe whereas the other planets move round the sun

epicycle. He considered circular orbits for planets but assumed that they actually move along a small circle with the centre on the original orbit (Fig. 5). This small circle is called an epicycle. On the other hand, earth is not placed at the centre of the concentric orbits but slightly displaced. The resulting eccentric orbits are called deferents. He further assumed that the periods of revolution of a planet along the deferent and the epicycle are same. By adjusting the degree of eccentricity of the deferent and the size of the epicycle, he was able to reduce the discrepancy between the theory and observations within the limit of experimental accuracy. For example, accuracy was within 10" of arc in the case of moon.

From the time of Ptolemy to Renaissance the theories of Aristotle, Ptolemy, etc., were considered to be

unquestionable and hence no new observations were made. Throughout these "Dark Ages" no new idea came forth and this was partly due to the influence of the powerful Christian dogma that the universe is geocentric. But during Renaissance, new observations began under the leadership of Nicholas of Cusa (1401-1464 A.D.), Georg Peurbach (1423-1461 A.D.), and others. According to Nicholas, the universe is infinite and so cannot have a centre. He also believed in the diurnal motion of earth. Georg Peurbach was a professor of mathematics and astronomy in the University of Vienna and discovered many errors in the *Almagest*. He tried to publish a revised edition of it but died before its completion. His disciple Regiomontanus (1436-1476 A.D.) took the job and finished it.

At this juncture came Nicolaus

Copernicus. He was born on 19th February, 1473 at Torun (now Thorn in Poland) and received his university education at Cracow in Poland and at Bologna and Padua in Italy. His subjects were medicine and law, and the study of astronomy and mathematics was his hobby. He returned to Poland in 1505 and obtained a canonry in the Cathedral at Frauenburg (now Frembork, Poland). This post ensured him lifelong financial security.

During his stay in Italy, Copernicus was attracted to the errors of the *Almagest* and became increasingly dissatisfied with the geocentric ideas. At the same time he became a firm believer of the heliocentric planetary system and was determined to establish it on a firm mathematical basis. After 31 years of tedious labour he published *Commentariolus*, an abstract of his research, in 1529. His fundamental propositions are as follows:

- (1) The movements of planets observed from earth are not absolute but relative as these observations are made from moving earth;
- (2) The celestial sphere (the sphere containing the stars) does not rotate. Its apparent motion is due to the diurnal motion of earth;
- (3) The annual motion of sun observed from earth is due to earth's motion around the sun; and

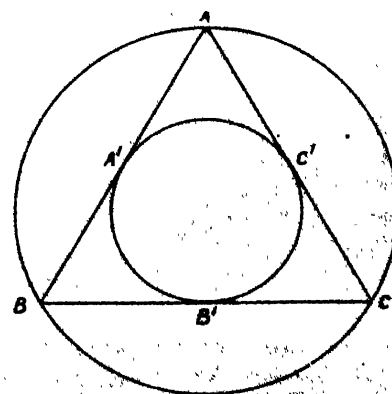


Fig. 8. Two circles ABC and A'B'C' are obtained by circumscribing and inscribing the equilateral triangle ABC. The process may be repeated for a square; a hexagon and other regular geometrical figures

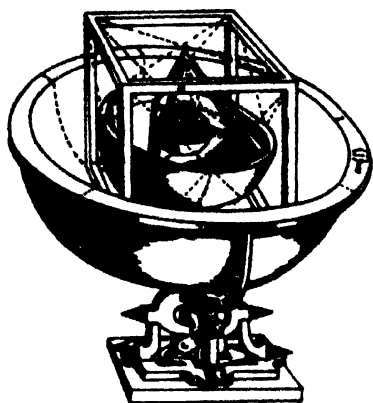


Fig. 9. Kepler's imagination of the radii of the planetary orbits. The outermost sphere represents the orbit of Saturn, the sphere inscribed into the cube is for the orbit of Jupiter and so on

(4) Sun and stars are fixed, and planets are moving round the sun in circular orbits.

At the end of the universe is the celestial sphere. The first movable thing is the planet Saturn completing its orbit in 30 years followed, successively, by Jupiter (12 years), Mars (2 years), Earth (1 year), Venus (9 months) and Mercury (80 days) (Fig. 6).

According to Ptolemy, the motion of earth was absurd. If a heavy mass like earth had any motion, it would have been broken up into fragments and the lighter objects would have flown away from it. Copernicus argued that if the motion of earth is discarded, the celestial sphere should rotate with an unimaginable velocity, which is more absurd. The next hurdle which he had to overcome was the parallax of stars. Copernicus said that since stars are at extremely large distances from earth, no parallax is observed. (This parallax has been measured and is found to be within 1' of arc).

On the other hand, Copernicus showed that if the motion of earth is accepted, the complex motion of other planets can be easily explained, without the help of imaginary ideas of deferents and epicycles of Ptolemy. But as the Copernican orbits were

circular, he was unable to explain all the mysteries of the planetary motion. It was beyond the imagination of Copernicus that heavenly bodies can move in an orbit other than a circle. He was in firm conviction that the planets, being the perfect creations of God, followed the most perfect of the orbits, namely circles. Nevertheless, he tried to reduce the discrepancies to a minimum by placing sun at considerable distances from the centre of the orbits and by considering epicycles for some of the planets. He took the help of 34 circles whereas Ptolemy utilized 79.

Although his theory was against the Christian dogma, Copernicus did not face any persecution due to two reasons. He himself being a cannon of the Church, it was difficult for the clergy to doubt that his works will do damage to the Church. Secondly, he died in the same year 1543 (at Frauenburg) in which his complete work "Revolucionibus" was published. He was destined to have a glance of the "Revolucionibus" only on his death bed. After his death, the Church realized the real danger of his theory and banned it. After nearly 300 years of its publication, in the year 1822, Roman Church declared that Copernican theory can be taught in educational institutions as an alternative explanation of the structure of the universe.

In the history of science, the man who comes next is not a theoretician but a great experimentalist or, in other words, a keen observer. He is Tycho Brahe (1546-1601 A.D.), the father of modern observational astronomy. Without his observations it would have been impossible for Johannes Kepler to get a correct idea of the planetary system. This Danish Astronomer was born on 14th December, 1546 at Kundstrup (now in Sweden). Tycho Brahe was attracted to the study of astronomy when he observed a solar eclipse in 1560 which took place according to predetermined calculations. He made his first recorded observation, a conjunction of Jupiter

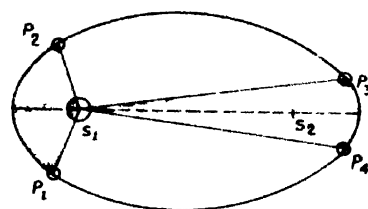


Fig. 10. Kepler's law of constancy of aerial velocity.  $S_1$  and  $S_2$  are the foci of the ellipse and sun is at  $S_1$ . The speed of a planet revolving round the sun varies in such a manner that the shaded areas  $P_1S_1P_2$  and  $P_2S_1P_3$  become equal in equal intervals of time

and Saturn, in 1563 and found previous observations grossly incorrect. In 1572, he discovered a nova (new star) in the constellation Cassiopeia which shook the Aristotelian doctrine that all changes take place within the lunar sphere and the space beyond the lunar sphere is immutable.

Tycho Brahe built a large observatory Uraniborg (the castle of the heaven) in the island called Hveen with the patronage of Fredrich II, the King of Denmark. His observations included a comprehensive study of the solar system and accurate positions of more than 777 stars. He invented and improved astronomical instruments and with the help of these delicate instruments and by his wonderful skill of observation introduced undreamed of accuracy into the celestial measurements. Unfortunately, after the death of Fredrich, he had to leave Uraniborg in 1593. He then came to Prague and began to build a new observatory there in 1598 with the financial assistance of Rudolf, the King of Germany but died (1601) before its completion. The year 1600 is remarkable in the history of science. In this year Johannes Kepler came to Tycho Brahe.

Tycho Brahe had a model of the universe of his own which is essentially a compromise between the heliocentric and geocentric schools. He discarded the idea of earth's motion as he was

unable to measure parallax with his most precision instruments and placed earth at the centre of the celestial sphere. To explain the annual motions of sun and moon he made them move round the earth and placed rest of the planets in circular orbits around the sun (Fig. 7).

Johannes Kepler was born in Stuttgart (W. Germany) on December 27, 1571. After studying astronomy and mathematics in the cloister school of Maulbronn at the University of Tübingen he became a supporter of the Copernican theory due to the influence of his teacher Michael Maestlin of the heliocentric school. In his childhood his father was in a rather solvent condition but later on reduced to keeping a tavern when Kepler was having his university education. So at the age of 22 Kepler had to accept a teaching job in the gymnasium at Gratz in Steyermark to assist his father and insane mother.

During his stay in Gratz, he began to find some relation between the radii of Copernican orbits. He had a firm conviction that the universe being a perfect creation of God it cannot be haphazard and there must be some relation between the radii of the planetary orbits. First of all he tried inscribing and circumscribing triangles, squares, hexagons and other regular geometrical figures and see if the two circles thus obtained would correspond with any two of the several planetary orbits (Fig 8). But the attempt was found to be a failure. It then came to his mind that, the universe being three dimensional, three dimensional geometry instead of a two dimensional one would be able to describe it properly. Furthermore, since Euclid had shown that there could be only five regular solids so one can, at best, get six spheres inscribing and circumscribing these regular solids.

The striking coincidence of this number six with the six planets discovered till that time assured Kepler that he was on the right track. From this viewpoint he represented the

earth's orbit by a sphere and around it circumscribed a dodecahedron and put another sphere around it. To his astonishment he found that this outer sphere coincides approximately with the orbit of Mars. Around the orbit of Mars he put a tetrahedron corners of which mark the sphere of orbit of Jupiter, and putting a square over it he found that the sphere circumscribing this square coincides very nearly with the orbit of Saturn. On the other hand, he inscribed in the sphere of the earth's orbit an icosahedron and inside the sphere determined by that an octahedron. The spheres determined by the icosahedron and the octahedron were found to agree with the orbits of Venus and Mercury respectively (Fig 9).

Kepler was very much delighted by this discovery and sent copy of his work to Tycho Brahe and Galileo Galilei. Both of them were attracted by the mathematical skill of this young man and, as a consequence, Tycho invited him to Prague (1600 A.D.) to join his research staff. But this imagined discovery is purely fictitious and accidental. Firstly, 9 planets are now known instead of 6, and secondly their real distances agree approximately with Keplers' hypothesis.

In 1601, after the death of Tycho Brahe, Kepler was placed in his position. In 1604 he published his work on aberration caused by the refraction of light in passing through the atmosphere. In 1609, he published his fundamental work *Astronomia ... Mortibus Martis Stella* containing his famous laws about the planetary motion.

In Copernican theory the discrepancy between the theory and observation was maximum in the case of Mars. On the other hand, he had at his disposal a large amount of accurate data for this planet collected by Tycho Brahe. For these two reasons he selected Mars for his calculations. He began with an eccentric (deferent) and an epicycle. The problem was to choose such an orbit

and such a law of speed, for both earth and Mars, that a line joining them when extended out to the stars, always marked correctly the apparent position of Mars as seen from the earth. By adjusting the degree of eccentricity and the size of the epicycle, he could at best reduce the discrepancy to 8' of arc. But due to his profound faith in Tycho Brahe's experimental skill and supreme faith on the accuracy of his collected data he could not neglect this 8'. He began to think whether a variable speed could reduce the error or not. In doing so he divided the eccentric orbit into triangles of equal area and found that the error reduces if the line joining the sun and the planet is assumed to traverse these triangles in equal intervals of time. But still he was feeling very uneasy as his theory was unable to reduce the error within the experimental accuracy of Tycho Brahe. Fortunately he observed that if the planet is made to oscillate along the diameter of the epicycle instead of rotating it along the circumference, the discrepancies vanishes as if by magic. He further noticed that if the planet makes one complete oscillation along the diameter of the epicycle during which it makes one complete rotation along the deferent, the resultant path becomes a well-known curve, namely, an ellipse where the eccentric point coincides with one of the foci of it. Thus he discovered first two fundamental laws of the planetary motion that; (1) the planets move round the sun in elliptic orbits keeping sun at one of its foci, and (2) the line joining the planet and the sun sweeps out equal area in equal intervals of time (Fig. 10).

The second law is generally known as the law of constancy of areal velocity.

Still, he could not get rid of his firm belief in the existence of a geometrical relation among the radii of the planetary orbits and, indeed, discovered the third law, 9 years after

the first two laws were discovered, in persuasion of this belief. According to this law if  $t$  be the time for one complete revolution and  $d$  be the average distance of a planet from sun,  $t^2 \propto d^3$  or  $t^2 = Kd^3$ .

Kepler's laws have been rigorously tested for all the planets and moon and have been found to be true even in the case of the satellites of Jupiter. The single exception is Mercury, but this is out of the scope of the present discussion. Kepler's laws enabled Isaac Newton to formulate his gravitational theory. Indeed, Kepler himself tried to establish some form of propelling force emanating from the sun, like the spokes of a windmill, to

make the planets move round the sun instead of the old ideas that the planets are carried round by angels or celestial intelligences. He also founded modern optics by postulating the ray theory of light.

Unfortunately, this sick and unhappy man had to fight against poverty throughout his life. During his latter years of stay in Prague, he had to run his family without any salary for years. During these days his only source of income was astrology or fortune telling. His wife and three children died of poverty and then he decided to leave Prague for Linz with a professorship. But on the way he died at Wurtemberg on 15th

November, 1630, unnoticed and penniless, in the midst of a political turmoil.

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**G**AMMA rays, X-rays, ultraviolet, visible and infrared light, microwaves and radiowaves are all electromagnetic radiations of different wavelengths and energy. They are, however, similar in one respect. They travel in space with the same velocity, i.e.,  $2.90 \times 10^{10}$  cm/sec. Our discussion here is confined to radiation of ultraviolet-infrared region which is commonly used in analytical chemistry.

The nature of radiations and their corresponding wavelengths are given in Table 1.

#### Ultraviolet and visible absorption spectra

The absorption of light energy by organic compounds in the ultraviolet and visible region involves promotion of electrons in  $\sigma$ ,  $\pi$  and  $n$ -orbitals

mainly located in atomic orbitals of oxygen, sulphur, nitrogen and the halogens.

The electronic transitions ( $\rightarrow$ ) which are involved in the ultraviolet and visible regions are of the following types :

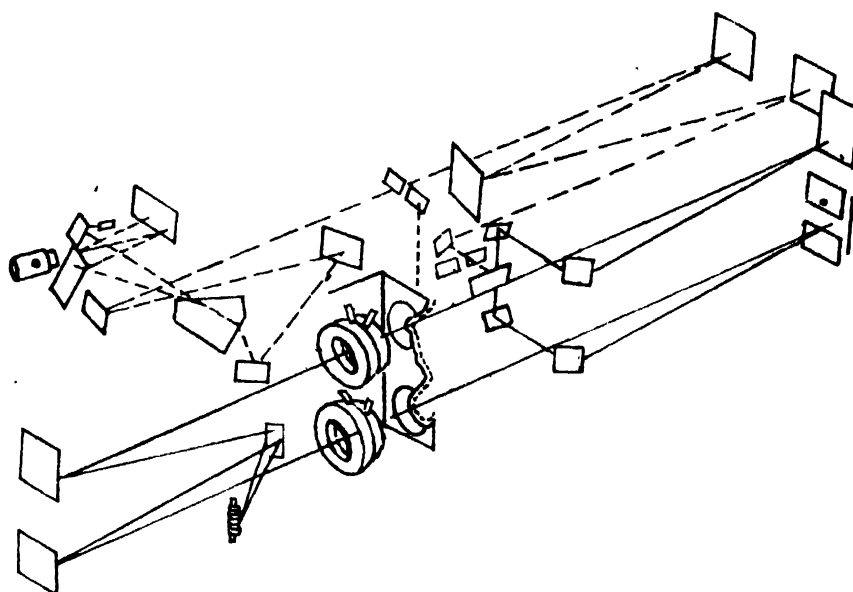
$\sigma \rightarrow \sigma^*$ ,  $n \rightarrow \sigma^*$ ,  $n \rightarrow \pi^*$  and  $\pi \rightarrow \pi^*$

The energy required for the  $\sigma \rightarrow \sigma^*$

H. C. CHAKRABORTTY

**When a molecule absorbs light energy, it increases its internal molecular energy in a variety of ways. A study of the absorption spectra can give information on its formula, structure and stability**

Molecules possess three types of internal energy needed for absorption spectroscopy : electronic, vibrational and rotational. When a molecule absorbs light, it increases its internal molecular energy in a variety of ways. Fig. 1 indicates different types of energy transformations. The various molecular energy states are quantized and the amount of energy necessary to cause the various types of transitions generally correspond to definite regions of the electromagnetic spectrum. Electronic transitions correspond to the ultraviolet and visible regions, vibrational transitions correspond to the near infrared and infrared regions, and rotational transitions correspond to the infrared and far infrared regions. A study of the absorption spectra can give information about the formula, structure and stability of absorbing species.



## ELECTROMAGNETIC RADIATIONS IN ANALYTICAL CHEMISTRY

from the ground state to the higher energy states. These higher energy states are described by molecular orbitals which are vacant in the ground state and are called antibonding orbitals. The antibonding orbital associated with the  $\sigma$  bond is called the  $\sigma^*$  (sigma star) orbital and that associated with the  $\pi$  bond is called the  $\pi^*$  (pi star orbital). As the  $n$  electrons do not form bonds, there are no antibonding orbitals associated with them. Non-bonding or  $n$  electrons are

transition is very high. Compounds in which all valence shell electrons are involved in single-bond formation, such as saturated hydrocarbons, do not show absorption in the ordinary ultraviolet region.

Molecules containing multiple bonds produce absorption in the near ultraviolet region. Isolated double bonds do not give strong bands but when conjugated systems are present, the bands are strong and in the longer wavelength region. The main use of

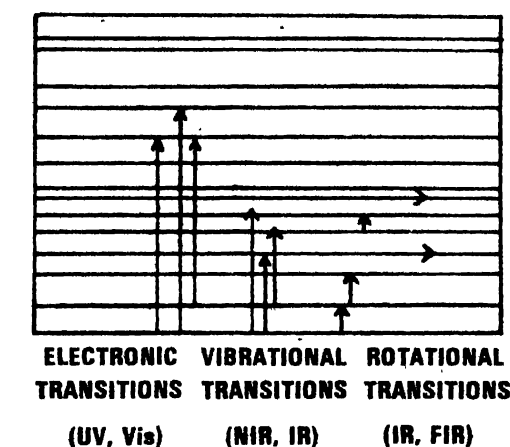
**Table 1. Radiations and their corresponding wavelengths**

Radiation	Wavelength ( $\text{\AA}$ )
Ultraviolet	2000-4000
Visible	4000-7500
Near Infrared	$7500-15 \times 10^4$
Far Infrared	$15 \times 10^4-100 \times 10^4$

the ultraviolet absorption spectra is in the detection of the conjugation and the elucidation of the nature of the conjugated systems.

Some terms are used in ultraviolet and visible spectroscopy. A chromophore is a structural feature which produces light absorption in the ultraviolet region or produces colour in the visible region. An auxochrome is a group which increases the absorptivity of a chromophore. Compounds possessing similar structure show similar absorption spectra. Hence the structure of a new compound may be interpreted by comparing its absorption spectrum with the spectrum of known compounds.

In order to obtain useful information from the ultraviolet or visible spectrum of a compound, the procedure followed is to measure accurately the wavelength of maximum absorption and also the intensity of the absorption. The compound is dissolved in a suitable solvent and the solution is placed in a cell which is transparent to radiation in the region to be studied. Glass cells are used for the visible radiation. Quartz cells are used for the ultraviolet radiations as glass absorbs ultraviolet light. The cells commonly used have 1 cm path length. Modern spectrophotometers provide a plot of the intensity of transmitted or absorbed light versus wavelength. The hydrogen discharge lamp is used for the ultraviolet light ( $200 \text{ m}\mu - 400 \text{ m}\mu$ ) whereas the tungsten filament lamp is used for the visible region ( $400 \text{ m}\mu - 750 \text{ m}\mu$ ) of the spectrum. Most of the spectrophotometers are double beam instruments. The



**SECOND ELECTRONIC EXCITED STATE**

**FIRST ELECTRONIC EXCITED STATE**

**ROTATIONAL STATES**  
**VIBRATIONAL STATES**

**GROUND ELECTRONIC STATE**

**ELECTRONIC TRANSITIONS**  
**VIBRATIONAL TRANSITIONS**  
**ROTATIONAL TRANSITIONS**

**(UV, Vis)**      **(NIR, IR)**      **(IR, FIR)**

Fig. 1

primary source of light is split into two beams, one of which passes through the cell containing the sample solution and the other passes through the cell containing the reference solvent. The spectrophotometer electronically subtracts the absorption of the solvent in the reference beam from the absorption of the solution in the sample beam. Thus the effects due to the absorption of light by the solvent are minimised.

Experimental results are usually reported in terms of the molar extinction coefficient or its logarithm,  $\log \Sigma$ . When the molecular weight of a sample is unknown, the intensity of absorption is expressed as the  $E_{1\text{ cm}}^{1\%}$  or  $A_{1\text{ cm}}^{1\%}$  value, the absorbance of a 1% solution of the sample in a 1 cm cell. This value is related to the molar extinction coefficient by the expression

$$10 \Sigma = E_{1\text{ cm}}^{1\%} \times \text{mol. wt.}$$

### Infrared spectroscopy

Molecules are made of atoms connected by chemical bonds which act very much as springs. These atoms or atomic groups are in continuous motion with respect to each other and each molecule has a specific vibration. There are two kinds of molecular vibrations :

(a) stretching, in which the distance between two atoms increases or decreases but the atoms remain in the

same bond axis, and (b) bending or deformation in which the position of the atom changes relative to the original bond axis. The various stretching and bending vibrations of a bond occur at certain quantized frequencies. When infrared light of the same frequency is incident on the molecule, energy is absorbed and the amplitude of the vibration is increased. When the molecule reverts from the excited state to the ground state, the absorbed energy is released as heat.

For chemical analysis of samples by infrared radiation, the samples are placed in one beam of a double beam infrared spectrophotometer. In such spectrophotometers the intensity and wavelengths of transmitted radiations are measured and compared with standard wavelength ( $2.5\mu - 15\mu$ ) or wave number ( $4000 - 650 \text{ cm}^{-1}$ ) charts. The source for the infrared radiation is the heating element, nichrome, which is heated to about

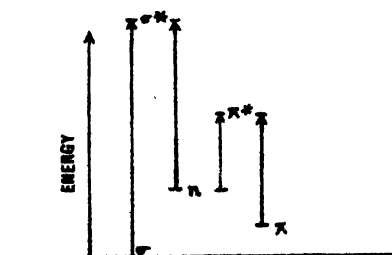


Fig. 2. Schematic electronic excitation energies

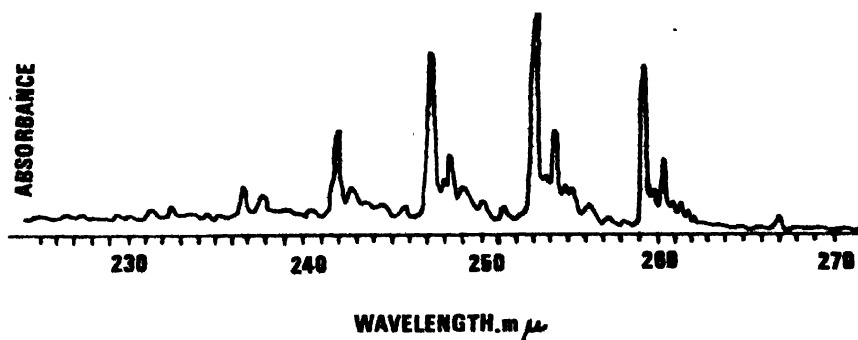


Fig. 3. Ultraviolet spectrum of benzene: vapour

1500°C by electrical means. Either optical prisms or gratings are used to obtain monochromatic light. Glass and quartz absorb strongly throughout most of the infrared region, so they cannot be used as cell containers or as optical prisms. Metal halides (e.g., sodium chloride) are commonly used for these purposes.

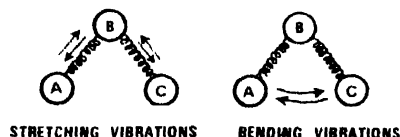


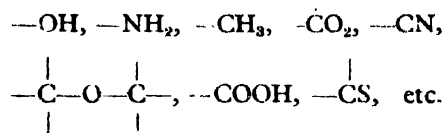
Fig. 4. Vibratory motion in a molecule

In infrared analysis, dry samples are always used as moist samples containing water absorb strongly near  $2.7\mu$  ( $3710\text{ cm}^{-1}$ ) and near  $6.15\mu$  ( $1630\text{ cm}^{-1}$ ). These absorptions may mask the absorption of the hydroxyl groups of the sample.

The spectrum of a solid sample may be determined either as a KBr "disc" or as a "mull". In the former case about 1 mg of the sample and 100 mg potassium bromide are ground together finely, dried to remove moisture and pressed at elevated temperature under high pressure (at least 25,000 psi) into a small disc that measures about 10 mm in diameter and 1 mm - 2 mm in thickness. A clear pellet is obtained which consists of a solid solution of the sample in potassium bromide. Since potassium bromide

does not absorb infrared light in the region  $2.5\mu - 15\mu$ , a complete spectrum of the sample is obtained. In the latter case about 5 mg of the sample is ground to a very fine dispersion with a drop of suitable mulling agent, such as liquid paraffin (nujol). The spectrum of the mixture is then determined after being placed between two sodium chloride plates. The sodium chloride plates are 25 mm in diameter and 5 mm in thickness. The spectrum of a liquid sample may be

determined by spraying the sample in a thin film between the plates. The spectra for liquids and gases may also be obtained with the help of a special type of cells. The infrared spectrum gives basic information about the molecular structure of a compound. Organic compounds consist of different combinations of functional groups :



These subgroups have characteristic absorption bands in certain parts of the infrared spectrum and an unknown compound can be characterized by checking the presence or absence of one or more of these groups. The presence and location of absorption bands give information on how the atomic groups are assembled in the molecule. The region  $1400\text{--}650\text{ cm}^{-1}$  is known as the "fingerprint

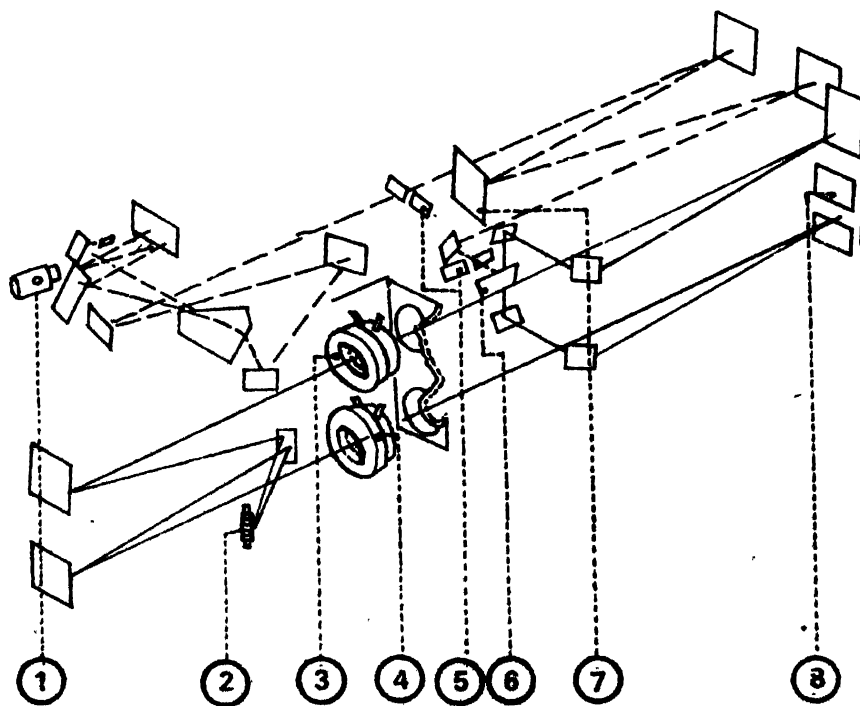


Fig. 5. 1-Thermopile, 2-Source, 3-Sample cell, 4-Reference cell, 5-slits, 6-oscillating mirror, 7-Grating, 8-Variable aperture



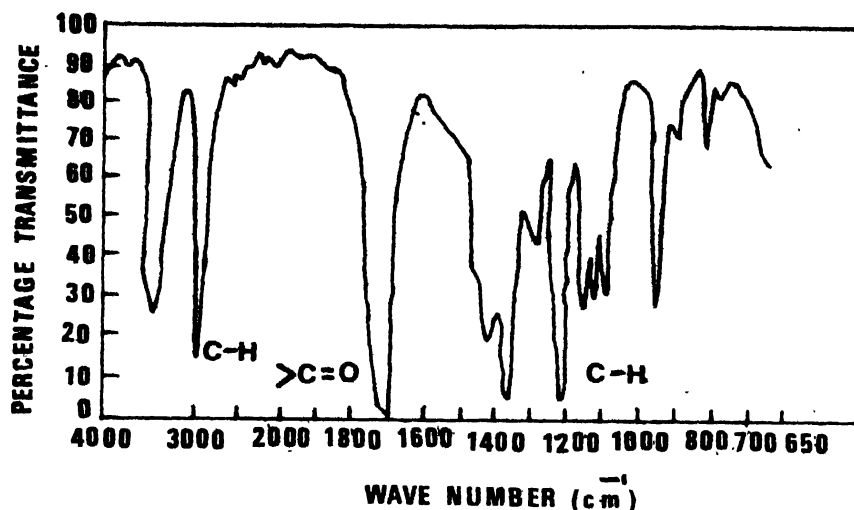


Fig. 6. Infra red spectrum of acetone

region". This region is checked for identification, since it is associated with vibrational and rotational energy changes of the molecular skeleton and so is characteristic of the compound. Aliphatic compounds produce generally few peaks in the spectrum whereas aromatic compounds produce quite a large number of peaks including fingerprints in the spectrum. Infrared is used for identifying unknown qualitative analysis, quantitative analysis, product control and permanent re-

cord. It may also help study progress of the chemical reactions from the nature of the absorption spectrum. As for example, a carbonyl compound can be reduced to an alcohol. If the reaction product shows the absence of the absorption band of the carbonyl group and indicates the presence of an alcoholic group, we can infer that the reaction is complete. We may also compare the identity of a synthetic compound with natural compounds by superimposing the spectra of na-

tural and synthetic compounds.

Infrared analysis finds application in agriculture, aircraft and missiles, air pollution, atomic energy, biochemistry, coal, coatings, cosmetics and essential oils, dairy products, drugs and narcotics, education, emulsions, food, inorganic compounds and minerals, medicine, petroleum industry, pharmaceuticals, polymers, rubber, silicone chemistry, textiles, tobacco, toxicological analysis and waxes.

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## OF VIRUSES AND CANCERS (Continued from page 390)

of the host cell and later its normal control, resulting in malignancy? It is true that last few years of studies have revealed much, but not all, and there remain ample areas for further research in this interesting field of viral oncology.

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# TICK- BORNE DISEASES OF CATTLE

**These killer diseases of the cattle can be controlled by a simple combination of animal dipping and chemotherapy**

iosis, babesiosis and anaplasmosis belong to the genus *Theileria*, *Babesia* and *Anaplasma* respectively. The parasites have an intra-erythrocytic form which is readily detectable under microscope in a stained blood smear (Figs. 2, 3 and 4).

Not much information was earlier available on these diseases in India. Whatever information we have now, has been gathered during the last decade as a result of research on these diseases at various centres, particularly at the Department of Veterinary Medicine, Haryana Agricultural University, Hissar.

## **Theileriosis**

In India, theileriosis causes heavy mortality in infected animals. Cattle theileriosis is caused by four groups of *Theileria* organisms (Fig. 2), out of which two are found in India and the others in Africa, Britain, Australia, Japan, etc. In sheep and goats the disease is caused by two groups of organisms.

The incubation period in *Theileria* infection is 8 to 12 days with an average of 9 days. In fatal

**T**HE term "tick-borne diseases" includes diseases transmitted through a variety of ticks (insect parasites of animals). The important ones are theileriosis, babesiosis and anaplasmosis. The causative agents of these diseases are found inside the red blood cells of the animals and transmitted from one animal to the other, principally through the bite of infected ticks (Fig. 1).

This group of diseases is one of the main problems facing the world cattle industry today. About three-quarters of world cattle population are at "risk" of these diseases. The economic losses associated with tick infections are too great to visualize.

Tick-borne diseases were known in India since early part of this century, but they came to limelight only dur-

ing the last decade when extensive programme of cattle development was launched to bring about "white revolution" by introducing foreign strains into our indigenous animals. The exotic (*Bos taurus*) and cross-bred (*Bos taurus* × *Bos indicus*) cattle are more susceptible to these diseases than the indigenous cattle which has considerable resistance to these diseases and constitutes a large reservoir of the parasites. Most of the animals suffer during summer and rainy seasons though isolated cases may occur throughout the year. The seasonal incidence has been attributed to the higher activity of the vector ticks during these months and also to the stress of hot and humid climate prevailing then.

The causative agents of theiler-

cases the course of the disease is from 6 to 10 days with a mean of 12 days. The initial symptom in theileriosis is enlargement of the superficial lymph nodes with a marked febrile reaction ( $40.5^{\circ}\text{C}$  to  $41.5^{\circ}\text{C}$ ). Schizont infected lymphocytes may be obtained by needle biopsy from the swollen nodes or from the liver. Subsequently the cattle rapidly become emaciated and anaemic. Piroplasms can easily be detected in erythrocytes at this stage. Sometimes nervous excitement may be noticed in cerebral form of the disease. In sheep and goats the symptoms are similar to bovine theileriosis. Post-mortem examination of dead animals reveals markedly enlarged spleen and liver, kidney infarcts, oedema of the lungs and punched necrotic ulcers in the abomasum.

The diagnosis of the disease is mainly based on clinical symptoms such as fever, enlargement of lymph nodes, anaemia and demonstration of the parasite in stained blood smears and Koch's blue bodies in the lymph node biopsy smears.

Chemotherapy of tropical theileriosis is still in infancy, and so far no drug has been found to be fully effective under controlled experimental conditions. Success has been claimed by many treating clinical cases of bovine tropical theileriosis in enzootic areas with a number of drugs, viz., berenil and different quinine preparations usually tried in combination of tetracyclines. Encouraging results as reported by some authors might have been due to spontaneous recovery which is quite common in theileriosis. However, in a clinical case some beneficial effect may be observed with a combination of antimalarial and antibiotic preparation along with supportive therapy. When the animal is very anaemic, blood transfusion should be adopted. Cross-matching of blood to determine compatibility is not often necessary for the first blood transfusion. However, a small amount of blood (50 ml-100 ml) is injected first and the animal is



Fig. 1. Life cycle of the three host cattle tick; A. Adult female; B. Adult male (adopted from M. C. Cooper; Dougall & Robertson Ltd., Berkhamsted England); 1. Larvae hatch from eggs laid on the ground and attach to a host after questing on pinnacles of vegetation; 2. They attack usually on the head and muzzle and engorge with blood; 3. Engorged larvae drop to ground to moult; Nymphs emerge. 4. Nymphs attach to another host, on the head and fore quarters and engorge with blood; 5. Engorged nymphs drop to ground to moult. Adult males and females emerge; 6. They find a third host and attach usually within the ear pinna. Fertilization occurs on the host; 7. After her final blood meal, the engorged female drops to ground four to seven days after attachment and lays eggs.

observed for about half an hour. If no transfusion reaction occurs, the remaining blood is given intravenously by drip technique.

Immunology of *Theileria* infection is not very clear. Animals after recovery from infection by one strain resist reinfection with the same strain but may not be completely protected against another strain, if the second strain is more virulent than the first. Thus relapses may be seen in animals after recovery.

The immunity in theileriosis is cell-mediated. Humoral antibodies are only of diagnostic significance as administration of immune sera to

susceptible animals does not alter the course of *T. annulata* infection.

### Babesiosis

Babesiosis is another important disease of animals and occurs in cattle, horses, sheep, goats, pigs and dogs. A few reports have appeared in literature about its occurrence in human beings also. It has a worldwide distribution and is recognised as a serious problem of major economic importance. It causes losses due to the death, decreased production and lowered working efficiency of the affected animals.



Fig. 2. Microphotograph taken from blood smear of a calf showing high parasitaemia of *Theileria annulata*  $\times 1000$

A number of *Babesia* species (Fig. 3) affect the animals, and under natural conditions all are transmitted from affected to healthy animals through various species of ticks.

All *Babesia* species tend to cause similar symptoms in infected cattle viz., high fever ( $40^{\circ}\text{C}$ - $41^{\circ}\text{C}$ ), anaemia, and haemoglobinuria (haemoglobin in urine but *B. bovis*, in addition, causes cerebral), babesiosis which results from the tendency of infected erythrocytes to clump, thus blocking the capillary blood vessels of the cerebral cortex.

In equines there is intermittent fever, signs of colic and oedema of head and dependent parts.

In dogs the main symptoms are high fever, anaemia, jaundice and haemoglobinuria.

Some cases have also been recorded in human beings and the main symptoms are chill, high fever, anaemia, jaundice and sometimes haemoglobinuria.

Post-mortem changes vary widely according to the severity of the disease. However, some features are common to all cases, viz., swollen and jaundiced

liver, yellowish discolouration of subcutaneous tissue, and pulmonary oedema.

Diagnosis of the disease is not difficult. Clinical symptoms, viz., fever, jaundice, haemoglobinuria and anaemia, are suggestive of babesiosis. For confirmation, blood smears from suffering animals can be examined for the presence of intra-erythrocytic stages of the parasite. A positive blood smear confirms the diagnosis but negative smear does not eliminate it. Diagnosis of subclinical or carrier cases of babesiosis is extremely difficult by conventional methods, hence serological diagnosis is necessary.

A number of drugs like Quinuro-nium and Diamidine derivatives, Amicarbalide and Imidocarb dipropionate have been successfully used for the treatment of babesiosis in animals.

It was believed earlier that there is premunity in babesiosis but some recent workers have demonstrated that immunity is not dependent on the presence of infection as the recovered animals may remain immune for periods of upto several years when no organisms could be demonstrated. It has also been observed that hyper-immune serum when injected to sus-

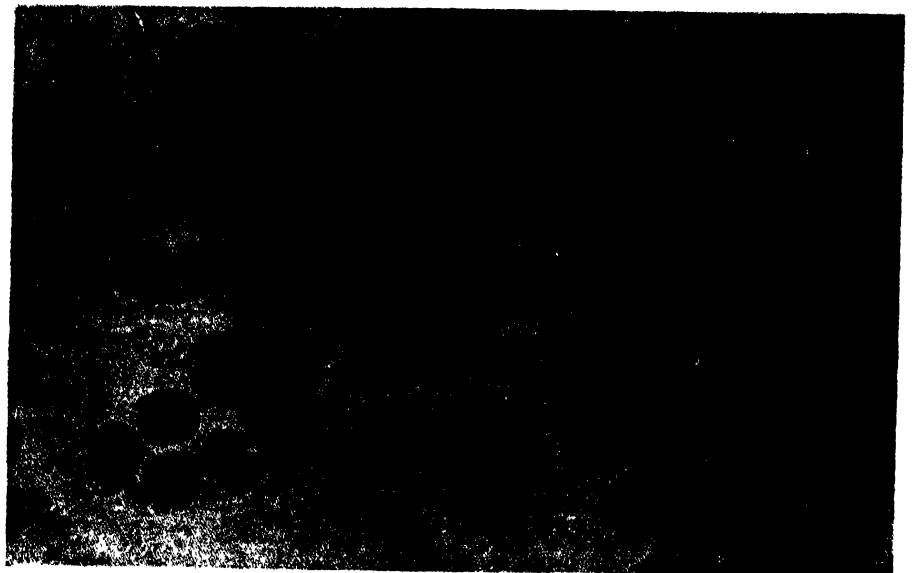


Fig. 3. Microphotograph taken from blood smear of a calf showing high parasitaemia of *Babesia bigemina*  $\times 1000$

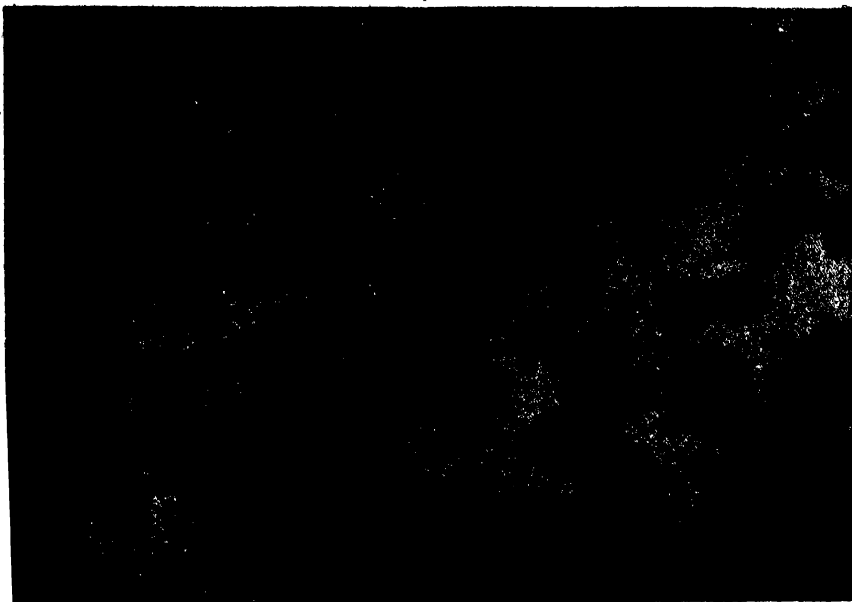


Fig. 4. Microphotograph taken from blood smear of a calf showing high parasitaemia of *Anaplasma marginale*  $\times 1000$

ceptible animals, protects them against lethal babesiosis and dead antigenic material may induce protection. The long survival of the parasite in the infected host perhaps provides frequent opportunities for transmission to the vector.

#### Anaplasmosis

Anaplasmosis is another important disease and affects cattle, sheep and goats. In cattle the disease is caused by *Anaplasma marginale* (Fig. 4) and in sheep and goats by *A. ovis*.

Anaplasmosis occurs over a very wide geographical range in the tropics and sub-tropics including India. Its principal vectors have not been accurately determined although ticks of different species are thought to play a significant role. The disease is so readily transmitted mechanically that it is difficult to ascertain the relative importance of its vectors.

The main symptoms are high temperature ( $40.5^{\circ}\text{C}$  to  $41.5^{\circ}\text{C}$ ), loss of appetite, constipation and sometimes abortions in pregnant animals. Anaemia followed by jaundice is a

pathognomonic symptom of the disease. On post-mortem examination the carcass is found emaciated with enlarged liver and spleen.

Diagnosis of the disease is not difficult. Symptoms like fever, anaemia, jaundice and debility are suggestive of anaplasmosis. However, the disease should be confirmed by examining stained blood smears for the presence of *Anaplasma* organisms. Capillary tube agglutination test has also been employed successfully to detect chronic cases. Cases of anaplasmosis are successfully treated with Tetracycline group of compounds. Encouraging results have been obtained by the use of Reverin (rolitetracycline), L-ethoxyethylglyoxal dithiosemicarbazone (gloxazone) and Imidocarb.

Both humoral and cell-mediated immune responses are observed in *Anaplasma* infection. However, serum from convalescing animals has not been found to confer protection against anaplasmosis; it is active only in serological tests. A gradual and balanced host-parasite interaction is necessary for development of cell-mediated immune response.

#### Control

The important thing in controlling the tick-borne diseases is that no single measure could ever be fully effective in eliminating them. It would need a combination of methods for reducing tick populations and tick-borne diseases. Tick populations may be reduced considerably by regular animal dipping or spraying of animals and their sheds and pastures with good tickicides. Incidence of tickborne diseases may be kept low by chemoprophylaxis chemotherapy and use of suitable vaccines. In certain developed countries where effective dipping has been combined with vaccination of animals against tick-borne diseases, good results have been obtained.

In Australia, South Africa and Central and South America, relatively unsophisticated but effective vaccines have been produced against the major tick-borne pathogens *Babesia* and *Anaplasma*. Production of such vaccines, if carefully monitored, may bring benefits to other developing countries as well.

So far as theileriosis is concerned, there have been a few attempts to produce a vaccine. An attenuated tissue culture vaccine has been produced in Israel and Iran, but the vaccine has its own limitations and is not very successful under field conditions. Recently an 'infection-and-treatment' method of protection against theileriosis has been worked out in this laboratory and is worthy of trial under field conditions on a limited scale.

Methods are available for protection against all the major tick-borne diseases of cattle so far evaluated. However, it would be incorrect to suggest that they are perfect and there are research results which indicate that there are problems with some of them. Nevertheless, if these are used while other more sophisticated ones are being developed, there is no doubt that a great deal of cattle mortality would be avoided.

(Continued on page 420)

**Viruses are known to cause tumours in experimental animals, but there is no conclusive evidence to show that they also cause cancer in man**

**I**T has long been known that human beings, and probably all animals, commonly harbour viruses as long standing latent infections, sometimes lasting for life. But the important question remains unanswered: Are these viruses related to cancer?

About 200 years ago, Bernard Peyrilhe of France, believing that cancer might be caused by a 'specific virus', injected subcutaneously fluid from human breast cancer into a dog. This was 25 years before Edward Jenner inoculated a boy with 'fluid from cow-pox vesicles' which successfully protected him against infection with smallpox virus. Although the experiment of Peyrilhe was itself not successful, the idea was kept alive in the minds of a few investigators until the present century, and now viruses as etiological agents in cancer are known to be commonplace.

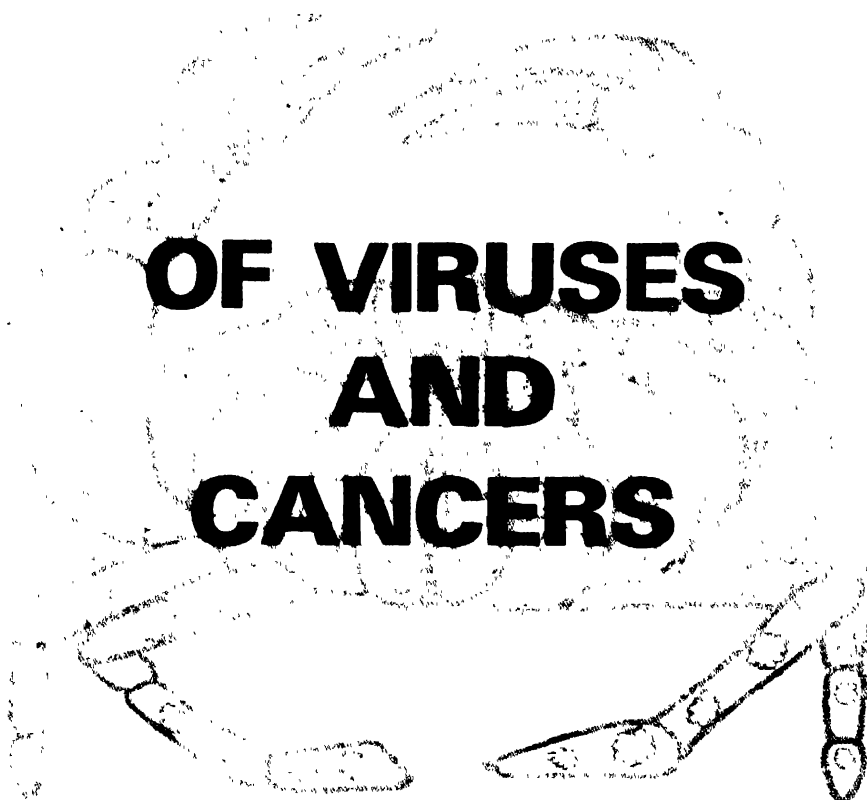
Although the viral origin of avian leukemia and avian sarcoma (tumour of the connective tissue) was discovered early in this century by V. Ellerman and O. Bang (1908) in Denmark and Peyton Rous (1910) of the USA respectively, the field of viral oncology has received wide attention only recently. Although no true cancers of man have yet been shown to be caused by viruses, there are a number of viruses that cause tumours in other animals under laboratory conditions.

#### **Oncogenic viruses**

More than 40 different viruses have now been identified which are oncogenic in nature, that is, capable of producing tumour in a wide variety of animals. Oncogenic viruses can be grouped into two main

categories on the basis of their physical, chemical and biological properties; those which contain ribonucleic acid as their genetic material and referred to as RNA tumour viruses or oncornav-

of their antigenic make-up, host range and type of malignancy they cause (Table 1). In general, RNA viruses are morphologically very similar; all are more or less spherical in shape



viruses, and those which contain deoxyribonucleic acid as their genetic material, termed as DNA tumour viruses.

The RNA tumour viruses which have been well studied can be divided into six different groups on the basis

with a lipid coat surrounding the RNA core. Encasing the RNA core there is also an icosahedral-shaped protein shell built up from protein capsomers (Fig. 1).

The known DNA viruses are a more diverse group of agents than the

RNA tumour viruses. They range from the small, comparatively simple papovaviruses to members of the much larger and more complex herpes viruses and poxviruses (Table 2). SV40 (a monkey virus) and polyoma (a mouse virus) are two common DNA viruses that can induce tumour in a wide variety of animals.

The diversity among the DNA tumour viruses makes it difficult to describe in detail their chemical and physical properties. In general, almost all DNA viruses exhibit cubic symmetry, the basic structure being that of an icosahedron (Fig. 2). Only the herpes viruses possess a lipid containing envelope.

It was previously believed that the action of each of the tumour viruses was restricted to one particular host, but recent investigations have shown that many of the tumour viruses are able to induce tumour in more than one species. For example, some forms of Rous sarcoma virus (named after the discovery by Peyton Rous) can induce tumour both in birds as well as in mammals.

#### Carcinogenesis by viruses

The precise mechanism by which

viruses render cells malignant and the way they differ from ordinary cytocidal viruses (virus that kills the cell) are problems which have not yet been totally resolved. Infection of a cell by a cytocidal virus results in cell death, whereas infection by a tumour virus leads to a synchronous virus-cell coexistence which results in profound changes in the properties of the infected cell. The application of some new techniques to the study of virus-cell interactions in tissue culture has brought some understanding of the mode of action of at least some oncogenic viruses.

When living fibroblast cells in culture are exposed to SV 40 particles, there are two possible manifestations of the infection. The virus may grow vegetatively by exploiting the nutrients of the host cell and ultimately release a large number of newly synthesized virus particles (Fig. 3a). Such a cell in which virus can multiply is said to be a permissive cell (Fig. 4). Alternatively, the cells may survive and some of them may show altered hereditary properties typical of cancer cell (Fig. 3b). The second effect due to virus infection is called neoplastic transformation. This activity of the

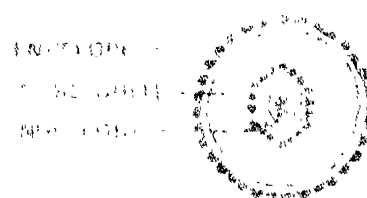


Fig. 1. The virion of RNA tumour virus

virus, leading to transformation of a normal cell into a tumorous one, can easily be recognised in cell cultures because transformed cells show altered growth characteristics (Fig. 5). These include increased and faster rate of growth, capability of unlimited passage in tissue culture, loss of contact inhibition, appearance of virus-specific antigens, tumour formation, etc.

The decision as to whether virus production or neoplastic transformation will come into effect depends largely upon the cell itself. It is known that both the hereditary properties and the physiological state of the cell influence the course as to whether a cell will be transformed into a tumour cell or it will die after devoting its

Table 1. Some properties of RNA tumour viruses

<i>Virus types</i>	<i>Abbreviated as</i>	<i>Host of origin</i>	<i>Natural tumours</i>	<i>Virion morphology</i>
<i>Avian Complex</i>				
Leukemia	ALV	Chicken	Yes	C*
Sarcoma (Rous)	RSV	Chicken	Yes	C
<i>Murine Complex</i>				
Leukemia	MuLV	Mouse	Yes	C
Sarcoma	MSV	Mouse	No	C
Murine mammary tumour (Bittner)	MTV	Mouse	Yes	B*
<i>Feline Complex</i>				
Leukemia	FeLV	Cat	Yes	C
Sarcoma	FeSV	Cat	Yes	C
<i>Hamster Leukemia</i>	HaLV	Hamster	Yes	C
<i>Primate</i>				
Sarcoma		Monkey, Ape	Yes	C
Mammary carcinoma		Monkey	?	B

\*The terms 'C type' and 'B type' are based on morphological as well as certain antigenic and enzymatic difference of RNA tumour viruses.

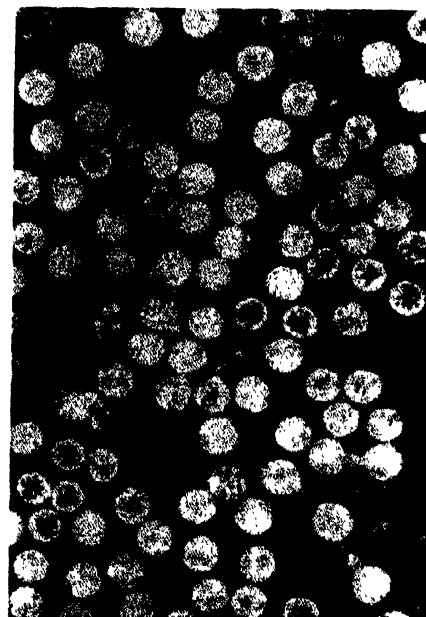


Fig. 2. Electron micrograph of SV 40 virus particles ( $\times 280,000$ )

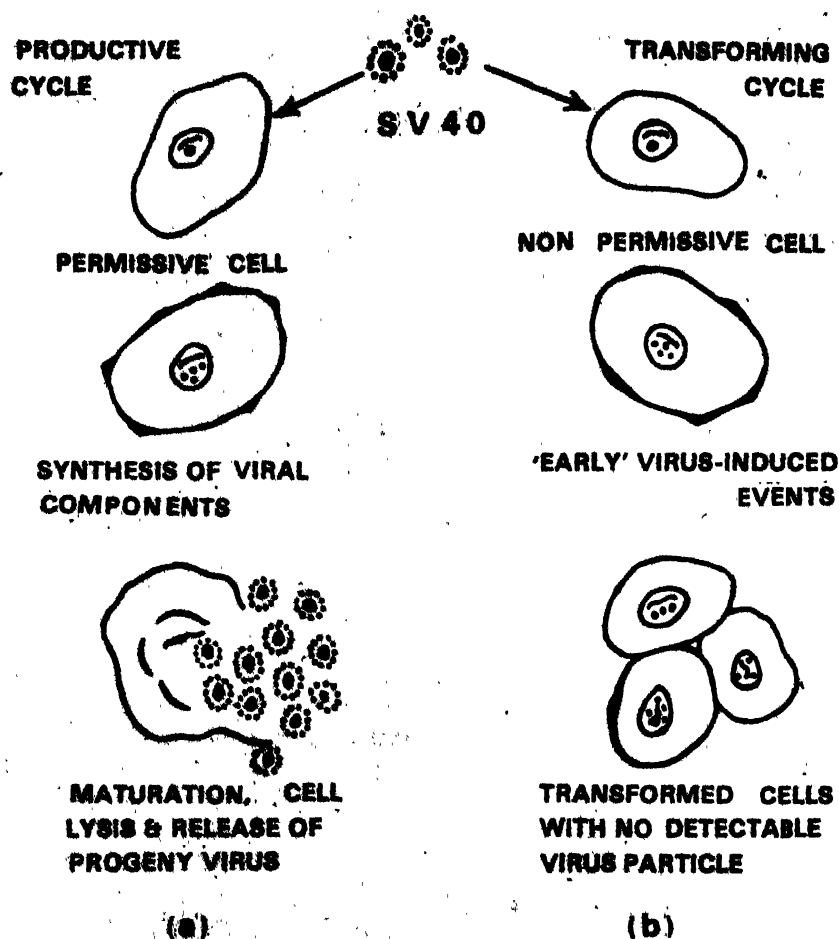


Fig. 3. Schematic representation of two types of interaction between a DNA tumour virus and a host cell; (a) productive; (b) transforming cycle

machinery for virus production. Besides the nature of the cell, the phase of the cell cycle and the amount of virus particle involved are also important (Fig. 6). Robert Suss and V. Kinzel of German Cancer Research Centre, Munich, have recently demonstrated that the growing and dividing cells at the onset of DNA replication are more suitable for viral transformation than stationary or so-called 'resting cells'.

Fig. 4. Electron micrographs of the release of tumour virions from different mammalian cell-lines (Courtesy : M. M. Lieber and G. J. Todaro of NIH, Bethesda, USA)



It is interesting to note that several thousand virus particles can be produced in one individual productive cell, whereas transformed cells appear to contain no virus at all. Although transformed cells do not contain any virus particles, the existence of viral DNA is frequently noted in the transformed cells and there are ample evidences that this foreign DNA has got some significance in neoplastic transformation. Recent DNA-RNA hybridization studies on SV 40 induced transformation has shown that each transformed cell contains some 1 to 20 SV 40 genomes (Fig. 7) integrated into the DNA of the host cell.

#### Involvement of viruses in human cancer

The progress made in understanding viral carcinogenesis in animals has offered new approaches in the quest for the possible viral etiology of at least some forms of human cancers. Attempts to demonstrate human cancer viruses were undertaken mainly in four different ways : (a) infectivity test, (b) using tissue culture for isolating the hypothetical viral particles, (c) direct examination of cancer cell under electron microscope, and (d) detection of virus specific antibody in the host cell.



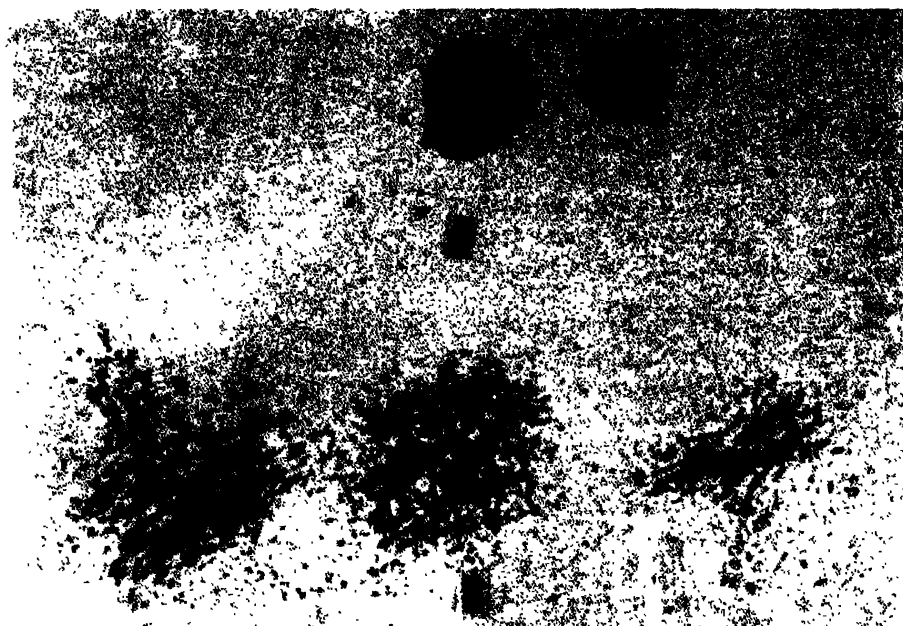
**Table 2. Some properties of DNA tumour viruses**

<i>Virus types</i>	<i>Host of</i>	<i>Natural</i>	<i>Size &amp;</i>	<i>Persis-</i>
		<i>tumours</i>	<i>symmetry</i>	<i>tence</i>
<i>Papova viruses</i>				
Papilloma	Man, Rabbit, Cow	Yes	40-55nm Icosahedral Symmetry	Yes
Polyoma	Mouse	No	Do	No
SV-40	Monkey	No	Do	No
<i>Adeno viruses</i>				
Human types (3, 7, 11, 12, 14, 16, 18, 21, 31)	Man	No	70-80 nm Icosahedral Symmetry	No
Simian	Monkey	No	Do	No
Bovine type 3	Cow	No	Do	No
Avian (CELO)	Chicken	No	Do	No
<i>Herpes viruses</i>				
Human type 2	Man	?	100 nm	No
EB viruses	Man	?	Icosahedral Symmetry	No
Monkey (Melendez)	Monkey	No	Do	?
Rabbit (Hinze)	Rabbit	No	Do	?
Avian (Marek)	Chicken	Yes	Do	?
Frog (Lucke)	Frog	Yes	Do	?
<i>Pox viruses</i>				
<i>Molluscum contagiosum</i>	Man	Yes	230 x 300nm	Yes
Yaba	Monkey	Yes	complex	Yes
Fibroma-myxoma	Rabbit, Deer, and Squirrel	Yes	Symmetry	Yes

infection with the virus and the cancer of the cervix. The prevalence of herpes type 2 antibody in women having the disease was found to be much higher than the normal one. Further support to the oncogenic potential of herpes type 2 virus has been provided by R. Duff and E. Rapp (1978) of the College of Medicine, Pennsylvania State University, USA. These two scientists have demonstrated that this virus can cause malignant transformation of hamster embryo cells in culture. Moreover, from a virological point of view, HSV-2 is considered a causative agent for cervical carcinoma for two reasons: first, as mentioned earlier, it is transmitted venereally; second, because of its topological distribution, recurrent genital infections satisfy the requirement of adequate contact with the tissue in which malignancy appears.

The Epstein-Barr virus, a newly recognised and antigenically distinct member of the herpes virus group, has been found to be strongly associated with atleast two human malignancies :

A great deal of attention has been centered in recent years on herpes viruses of man as potential oncogenic agents. The accumulated evidence in this aspect is not conclusive by any means, but impressive in its totality. In fact, atleast five different herpes viruses are found in human beings. Three of which are prominently associated with human cancers; they are HSV-1 (Herpes Simplex Virus), HSV-2 and EBV or Epstein-Barr (EB) virus (named after the discovery by M. A. Epstein and R. D. Barr of Middlesex Hospital, London). Initially, the studies on possible involvement of herpes virus dealt primarily with HSV-2 and cervical carcinoma (tumour of the cervix), because HSV-2 was found to be venereally transmitted. Seroepidemiologic studies by E. Adam and his research associates (1972-1975) at National Cancer Institute, USA have shown a high degree of association between



**Fig. 5. Clones formed by transformed (A) and normal (B) mouse embryo cells after infection with a tumour virus. The transformed cells pile on top of each other; thereby forming a thicker and darker mass than do normal cells**

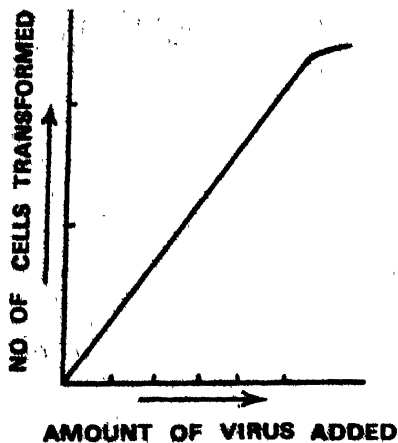


Fig. 6. The linear relation between the amount of SV 40 added to nonpermissive cells and the number of resulting transformed cells (Courtesy: *Molecular Biology of the Gene* by J. D. Watson; 3rd; Ed. W. A. Benjamin Inc.; Calif.; 1977)

Burkitt's lymphoma, a common cancer in African children discovered by D. Burkitt (a British surgeon working at Uganda) in 1962 which has been suspected from its geographical distribution to be due to a mosquito-borne agent; and nasopharyngeal carcinoma discovered by H.C. Ho in 1968 in Chinese male populations of South-East Asia. The finding of high incidence and high titre of EB antibody in patients with Burkitt's lymphoma and post-nasal or nasopharyngeal carcinoma led to the assumption that the association may be etiologic.

The important question as to whether EB virus is etiologically related to the above two malignancies or a passenger virus, present in lymphoid cells, trapped within the tumour, remains unanswered at present. The issue becomes further complicated because other viruses, such as herpes simplex virus and reovirus, have frequently been isolated from Burkitt's lymphomas. On the other hand, one cannot exclude the possibility that EB virus is one of the prime agents responsible for the induction of malig-

nancies in normal cells *in vivo*. The possibility that EB virus is an etiological agent is further strengthened by the recent *in vitro* experiments which have indicated that the virus can convert virus-free normal peripheral blood leukocytes into virus-positive cells capable of continuous growth.

#### Latent virus concept

Both herpes virus and EB virus are now known to be predominantly associated with a number of human cancers, albeit proof that they are definitely oncogenic in man still remains illusive. The discovery of latent RNA viruses in Burkitt's lymphoma and in certain other forms of human tumours has made the situation further complicated. A question which is often asked is: Are these viruses really responsible for tumour in man? If so, do they have any special gene which switches its host cells into malignancy? Or, do they act indirectly via a latent RNA tumour virus?

Recently, B. Hamper and S. Aaronson (1976) at the National

Cancer Institute, Bethesda, USA have provided evidence for the second possibility. They infected mouse cells by irradiated HSV's which are unable to destroy their host cells due to partial inactivation by UV light. To their surprise they noted that the infected mouse cells began to produce an endogenous virus, like the RNA tumour virus. From this and other accumulated evidences it seems likely that the role of latent RNA viruses is important in producing tumour but it is still too early to conclude whether herpes viruses cause cancer by awakening the latent RNA tumour viruses of the host cell from 'sleep'.

Despite the incredible facilities and tremendous advances in techniques in the field of virus research, certain crucial questions still remain unanswered: Are there really any human virus-induced tumours? If so, which are they and how many are there? By what means does the virus integrate into the genetic apparatus

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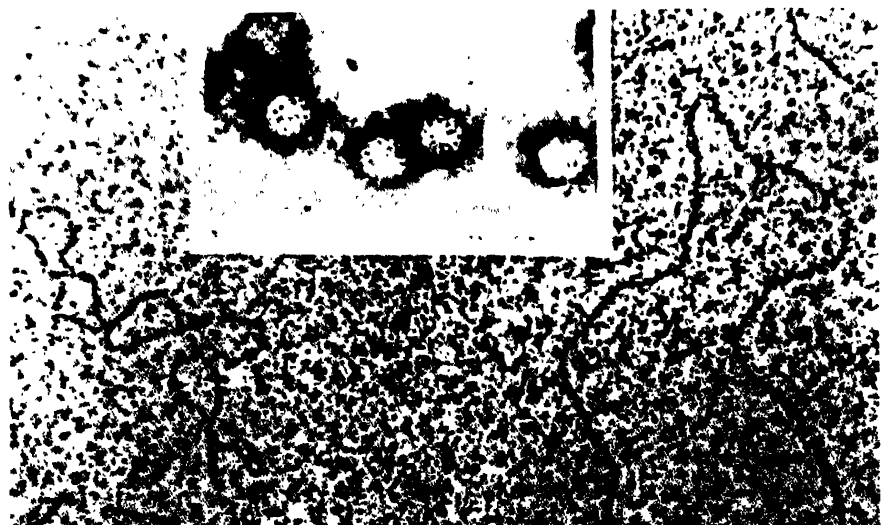


Fig. 7. Electron micrograph of the circular form of SV 40 DNA

# SCIENCE SPECTRUM

## Understanding somersaulting and twisting

**S**OMERSAULTING or twisting in air while taking a dive or gymnastics exercise looks to be a very simple manoeuvre. But, it is not so. It is the ease with which the highly trained people perform the feat that makes it look an easy job. Likewise, the physics behind somersaulting or twisting in air also appears simple, but again it is not so. How much thinking and re-thinking must have gone into understanding it can be appreciated from the fact that it is only now that a clear picture of it is emerging. But before the physics is explained, one has to brush oneself up with the concerned terms and concepts.

Consider first the human body in standing position, legs together and hands parallel to the body. There are two main axes, horizontal and vertical, about which the body can basically rotate. If the body rotates about its horizontal axis right through the trunk, it is said to be somersaulting. If the body rotates about its

vertical axis right through the head and toes, it is said to be twisting. All the manoeuvres in air, though look complicated, are basically a combination of somersaulting and twisting. Angular momentum, angular velocity and moment of inertia are the terms that one has to face in physics as soon as rotation of any body is to be considered.

Inertia is literally laziness—the tendency of a body to resist any change in its state of rest or motion. Moment of inertia is the tendency of a body to resist any change in its state of rest or rotation. It is the measure of the way the “particles” constituting a body are distributed around its axis of rotation, and also its mass. The more the particles of a body are away from the axis of rotation, the more is the moment of inertia of the body. For instance, the moment of inertia of the human body would be more about its horizontal axis, i.e., when it is somersaulting, rather than about its vertical axis, i.e., when it is twisting, although

the mass remains the same in both the cases.

Angular velocity is the rate of rotation of the body. It is a quantity which has both direction and magnitude, and so is a vector. The direction of the vector is parallel to the axis of rotation of the body. Angular momentum is angular velocity times moment of inertia of the rotating body. It is also a vector quantity and obviously the direction of vector is parallel to the axis of rotation of the body. It is clear that the angular momentum vector has the same direction as that of angular velocity vector. The moment of inertia is subjected to changes with changes in the distribution of “particles” in the body, the result of which is that moment of inertia and angular velocity can vary inversely with each other provided the angular momentum remains constant in direction and magnitude.

When a body somersaults it has a somersaulting angular momentum, and so has a twisting angular momentum when it twists, each angular momentum a product of its respective angular velocity and moment of inertia. The total angular momentum of a body, which executes a somersaults or twists, either one after another or simultaneously, is therefore the sum total of the somersaulting and twisting angular momentum. It is the basic law of physics that angular momentum of a rotating body is conserved when no external forces are acting on it. Which is why most people think this law violated when a body somersaults or twists in air (whose friction is considered negligible) without any help of an external force. It has, however, to be borne in mind that a body can execute a motion in mid-air by changing his somersaulting angular momentum and his twisting angular momentum—transforming one rotating force into another—as long as the total angular momentum remains constant in magnitude and direction.

**Axes of rotation in case of somersaulting (left), twisting (middle), and somersaulting and twisting simultaneously (right). In the last case, the total angular velocity vector (solid arrow) is the vector sum of the angular velocity of somersaulting (short broken arrow) and the angular velocity of twisting (long broken arrow)**

Take the case of a somersault. The person has to roll himself into a ball to execute this feat. By doing so, the person reduces his moment of inertia and as a result he spins head over heels, i.e., his angular velocity proportionately increases. When the person straightens himself up, the reverse process takes place, the total angular momentum remaining constant notwithstanding. Throughout the manoeuvre the angular velocity vector remains parallel to the angular momentum vector, both of which are parallel to the somersaulting axis as stated earlier. If, however, the person executes any other movement while somersaulting, the body does not rotate about either the somersaulting or twisting axis. It rotates about an intermediary, unsymmetric axis. Since the total angular momentum vector is the sum of twisting angular velocity vector times twisting moment of inertia and somersaulting angular velocity vector times somersaulting moment of inertia, first thing, and, secondly, both the moments of inertia are not

equal, the angular velocity vector no more remains parallel to angular momentum vector. The body therefore changes course in mid-air as long as the normalcy is not restored. (*Scientific American*, March 80).

Take the case of a twist. In this

Angular momentum vector (solid arrow) of a person executing a twisting somersault is the vector sum of the somersaulting angular momentum (long broken arrow) and the twisting angular momentum (short broken arrow)

case the person is already in air (after somersaulting, say). In that state his somersaulting axis is parallel to the total angular momentum vector, but no sooner the person raises one arm and lowers the other to execute a twist than the somersaulting axis no longer remains parallel to the initial angular momentum vector. The body continues to twist and in the process creates enough twisting angular momentum to keep the total angular momentum constant. To stop twisting the person has to move his body in such a way as to make the somersaulting axis parallel to the initial angular momentum vector.

In the above cases, the total angular momentum was always a non-zero quantity. But it has been seen that even when the total angular momentum is zero a body can twist. For instance, a cat let to fall upside down on its own, twists about itself in air to fall on its four paws. Zero angular momentum does not mean the body has to remain motionless. The body, flexible that it is, can

judiciously vary the moments of inertia of the body's upper and lower half—turning arms and upper trunk to right and legs and lower trunk to left—to twist in space. As soon as the body becomes rigid, it stops twisting.

Understanding the physics behind somersaulting and twisting looks like knowledge for knowledge's sake. But it is not so. Every knowledge has

also an application. The use of this knowledge would help astronauts to handle themselves in the gravity-less environment of space, in particular in orienting themselves to any posture by making minimum of movements. Also, the knowledge can be exploited by swimmers, gymnastics, etc., in breaking new records.

DILIP M. SALWI

## Danger of automobile exhaust on urban environment

ONE of the significant contributions of scientific knowledge to human comfort is the automobile. Paradoxically, every year the automobiles in turn release several thousand tonnes of toxic substances as exhaust in the biosphere. However, the ability of the atmosphere is limited in detoxifying the harmful exhausts. We thus become confronted by a spectrum of biologically waste materials, many of which are harmful to man and its concern. As a result these toxic contaminants trigger a chain of lethal reaction within the natural ecosystem.

The major automobile pollutants include carbon monoxide, lead, hydrocarbons, nitrogen oxides, sulfur oxide. The amount of these substances from auto-exhaust in any given locale depends upon the number of vehicles present there. Obviously the congested cities with a large number of vehicles in India are highly prone to the effect of toxic substances from auto-exhaust. Carbon monoxide and lead are the most lethal components of auto-exhaust to our environment and thus to ourselves. A few examples will support this contention.

### Component of auto exhaust

The fuel for automobile is gasoline. Several compounds like tetraethyl lead (62%), ethylene dichloride (18%), ethylene dibromide (18%) and other substances (2%) are added to gasoline for its effective combustion. Tetraethyl lead behaves as an antiknock agent for combustion. The halogens act as scavengers in reaction with lead during gasoline combustion. Through a series of chain reaction by the combustion of gasoline several lead compounds and carbon monoxide are released as exhaust by the automobiles. The important lead compounds include lead carbonate-lead oxide (30%), lead carbonate (14%), lead bromochloride (12%) and lead chloride (8%). After their release these compounds are conveyed far and near by air, and some parts of these substances gradually settle on plant parts. A certain amount is also conveyed to the soil and water.

### Effect of lead fallout of auto-exhaust on vegetation

Plants are contaminated with lead

from the fallout of auto-exhaust and through absorption from the soil by roots. Lead contamination from atmospheric fallout depends upon traffic density, proximity to roadways, strength and direction of winds and exposure time of plant organs. Airborne lead settles on leaf surface, bark and stems. Records from American cities show that plants accumulate 165 ppm of lead in highway with 900 cars/hr and 570 ppm lead with 2,700 cars/hr. The lead contents of vegetation, especially the edible portions which are consumed by man and other animals are measured in some western cities over a distance of several kms away from the highway. This has shown a high concentration of lead in edible vegetation and is regarded as detrimental to human health. As cabbage leaves and potato are found to contain 815 ppm, tomato 8 ppm and corn 45 ppm of lead. Again some edible vegetation like corn, radish, potato, lemon, etc., readily absorb lead through roots and a substantial amount of it is stored there. In some places barley plant is found to accumulate about 900 ppm of lead in roots. Experiments have shown that 30 ppm-40 ppm of lead is toxic to plants. It is found that high lead concentration inhibits photosynthesis and water absorption in plants and it also inhibits succinate oxidation in plant cell. This accumulated plant lead releases a chain of reaction on animals which feed upon them. In cattle high rate of mortality has been recorded after consuming lead contaminated grass and other vegetation. Men in their turn get poisoned by consuming milk and other body parts of cattle and lead contaminated vegetables.

As mentioned above, some portion of lead fallout from auto-exhaust also settles in the soil. It is found that earthworms succumbed after accumulating about 300 ppm of lead from soil. Several ducks of economic importance like mallard, pintail, etc., have died after consuming lead contaminated earthworms.

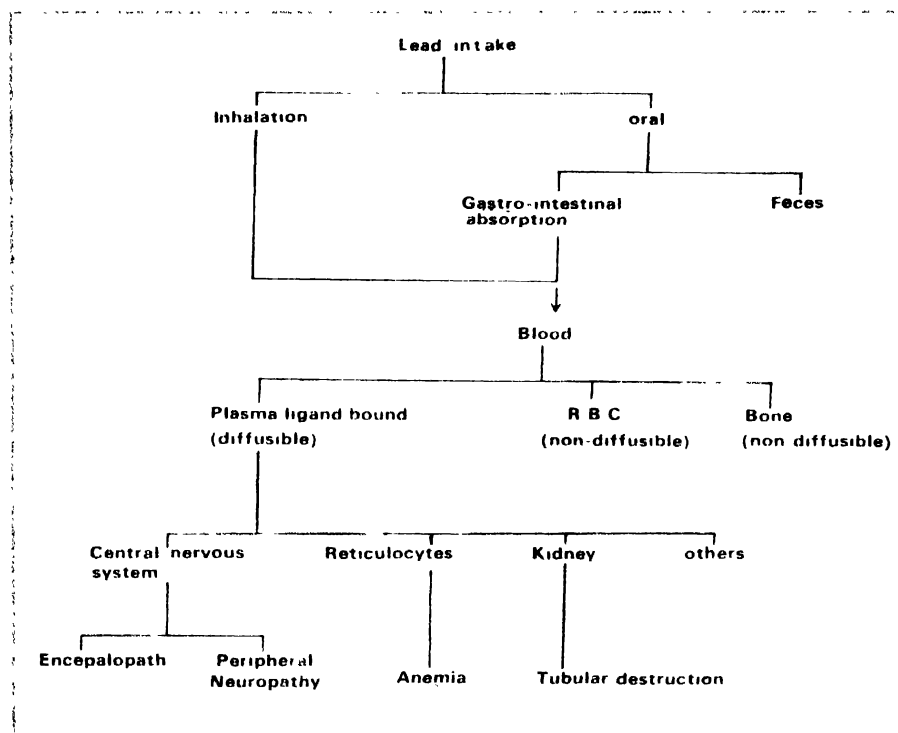


Fig. 1

### Effect of lead from auto-exhaust on man

Lead enters human body through the respiratory tract by inhalation of air contaminated with auto-exhaust and via food. Data collected by scientists in some western countries show that an urban adult breathing air containing  $3 \mu\text{g lead/m}^3$  and respiring about  $15 \text{ m}^3$  air per day will absorb  $20\text{--}25 \mu\text{g}$  of lead through the respiratory tract. And another  $25 \mu\text{g}$  of lead per day is absorbed through diet. It appears, therefore, that higher atmospheric lead concentration in any area as in vehicles, garage, automobile complexes and in congested cities will result in greater absorption of lead by inhalation. So people who work for a long time in such atmosphere like the cab drivers, traffic police men and automobile employees inhale much more quantity of lead. Data collected from some American cities show that traffic police and automobile employees contain

$30\text{--}35 \mu\text{g}$  of lead in  $100 \text{ ml}$  of blood as against  $16\text{--}23 \mu\text{g}$  of lead in  $100 \text{ ml}$  of blood in urban people. And the concentration of lead in non-urban people is found to be  $10\text{--}16 \mu\text{g}$  in  $100 \text{ ml}$  of blood. It is assumed that human blood level with more than  $60 \mu\text{g}$  lead  $100 \text{ ml}$  blood is harmful. Lead absorbed via lung and diet is circulated through the blood stream by binding with red blood corpuscles and to some diffusible organic ligands. This absorbed lead is stored in bones, liver, kidney, etc., and causes critical intoxication in haematopoietic tissue, central nervous system and peripheral nervous system and kidney leading to peripheral neuropathy, anemia and destruction of renal tubules (Fig. 1). Experiments have also shown that infants with blood lead level over  $100 \mu\text{g}$  day leads to encephalopath, growth retardation and depressive nervous activities. Lead intoxication in pregnant women results in abdominal pain headache, convulsion, etc., in new born baby and infants. Experiments

also indicate that sub-lethal concentration of lead alter the developmental process in children.

### Effect of carbon monoxide on man

Apart from lead carbon monoxide from auto-exhaust represents a major source of contamination to our environment. Data collected from the different cities have shown that the level of carbon monoxide in vehicles sometimes exceeds  $100 \text{ ppm}$  in peak hour of traffic movement. In more confined places like garage, underground parking areas, the level of carbon monoxide reaches upto several hundred ppm for extended period of times. Traffic police men, cab drivers and others who constantly work in areas of heavy vehicular traffic continuously experience some degree of sub-lethal poisoning. It has been shown that prolonged sub-lethal carbon monoxide poisoning can produce polycythemia (increase of red blood cells) and cardiac enlargement. Experiments have shown that at  $100 \text{ ppm}$  exposure carbon monoxide combines with a portion of haemoglobin. This compound haemoglobin (carboxyhaemoglobin) then no longer acts in transporting oxygen through the blood vessel. This is the important effect of carbon monoxide poisoning in man and other animals. Therefore, carbon monoxide concentration of  $100 \text{ ppm}$  represents the threshold for measurable polycythemic effect on man and other animals. Experiments have also shown that carbon monoxide concentration between  $100\text{ppm}\text{--}200\text{ppm}$  leads to cardiac hypertrophy (enlargement). It is also presumed that chronic carbon monoxide poisoning can produce some cellular biochemical alteration which has a close correlation with some cardiovascular stress like aortic pulmonary constriction, coronary artery disease and severe anemia. These effects become more intensified in people who use to work for a prolonged period in industrial complexes, in and around automobiles,

etc. having high concentration of carbon monoxide.

It is, therefore, most urgent to make periodic check of lead and carbon monoxide concentration in urban people, particularly of traffic police men, cab drivers and other persons who work for long hours in the environment of high lead and carbon monoxide

concentration and to take all necessary steps to minimise their poisoning effect on man and its concern from the auto-exhaust.

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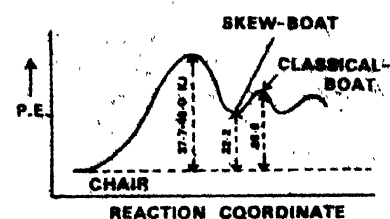


Fig. 2

## Cyclohexane

THE word cyclohexane takes our mind to that organic liquid, enclosed in a bottle, with which the organic chemist is so well acquainted. A mere look at the liquid hardly reveals its mysterious forms of existence that had baffled organic chemists for quite some time.

Cyclohexane is a simple alicyclic organic molecule. The molecular formula of cyclohexane is  $C_6H_{12}$ . The very term "alicyclic" suggests that the molecule is aliphatic as well as cyclic in character. Fig. 1a gives a simple illustration of the cyclohexane molecule. A look at Fig. 1a would lead many of us into believing that all the six carbons of the cyclohexane molecule are in one plane and that the molecule as a whole resembles a regular hexagon. However, this is not true.

The existence of cyclohexane as a regular hexagon with all carbon atoms in one plane is not energetically feasible.

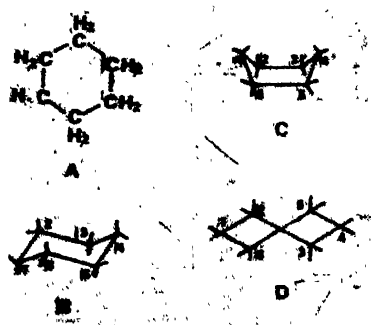


Fig. 1

Existence in a regular hexagonal form requires the bond angles to be  $120^\circ$ , which would bring about a marked deviation from the normal tetrahedral angle of  $109.5^\circ$ . This in turn would give rise to tremendous strain and the formation and existence of a molecule under such strain is not possible. Therefore the cyclohexane molecule has to exist in a form in which such strains are minimized and also energetically the molecule is stabilized.

Cyclohexane exists in two extreme conformations in which all the angles are tetrahedral. However, strictly speaking, the angles are not  $109.5^\circ$  but  $111.5^\circ$ . This slight deviation from the normal tetrahedral angle produces a small amount of angular strain in the cyclohexane molecule.

The two conformations in which cyclohexane molecule can exist are the chair form (Fig. 1b) and the boat form (Fig. 1c). These two forms are also known as conformers. The two conformers have been so named because one looks like a chair and the other like a boat.

While discussing the cyclohexane molecule we find that we have stepped onto a new term called conformations. Now what are conformations? "Conformations or conformers are different three-dimensional arrangements in space of atoms in a molecule which are interconvertible merely by free

rotation about bonds". The chair and the boat conformations of cyclohexane are also interconvertible.

The chair and the boat conformations of cyclohexane are both puckered. An energy barrier of 37.7 to 46.0 KJ/mole exists between the two conformations. The chair form is more stable compared to the boat form. Though this energy barrier makes the existence of the two forms possible, yet at room temperature it is not sufficient to allow the two forms to retain their identity and in consequence there is rapid interconversion between the two forms. Thus it is not possible to isolate each conformation.

Intermediate between the chair and the boat form there exists the skew boat (twist boat) form (Fig. 1d) which is the twisted conformation. On changing from one form to the other, the cyclohexane molecule has to pass through the intermediate skew boat form. This is clearly demonstrated in the energy diagram (Fig. 2).

Electron diffraction studies have shown that at room temperature the cyclohexane molecule exists mainly in the chair conformation. Some molecules do exist in the boat form but their number is comparatively small.

A small scrutiny of the cyclohexane chair shows that six of its bonds are directionally different to the other six. Each carbon has a bond which is directed up or down and are called

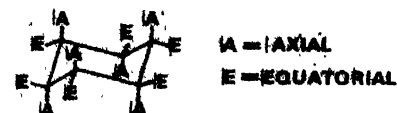


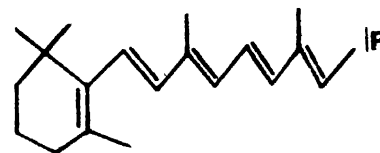
Fig. 3

axial bonds. The remaining six bonds which are in the plane of the ring are called equatorial bonds (Fig. 3).

The discovery of the stereochemistry of the cyclohexane molecule opened a new chapter on conformational analysis and studies and hence has

aided the organic chemist tremendously in their exploration of new arenas in organic chemistry.

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R = CH<sub>2</sub>OH Retinol

R = CHO Retinal

R = COOH Retinoic acid

Fig. 1

## Vitamin A, retinoids and cancer

VITAMIN A is well-known to everybody for its importance in general growth, the growth and epithelial cell differentiation, the development of malignancy in epithelial tissues, visual function and reproduction. The term 'Vitamin A' is now used when reference is made to the biological activity of more than one vitamin A active substance which includes retinol, retinal, retinoic acid, etc.

### Vitamin A compounds

As suggested by M. B. Sporn of National Cancer Institute, Bethesda, Maryland, USA, both natural forms and the synthetic analogs of vitamin A are termed as retinoids. In past few years, excellent work done in the laboratory of Sporn has shown that retinoids may be used to prevent cancer of the skin, lung, bladder, and breast in experimental animals. The rationale for use of retinoids in prevention of cancer is straight forward: The great majority of human cancers arise in epithelial target sites such as lung, bladder, breast, colon, pancreas, esophagus, stomach, uterus, prostate, and retinoids are known to be required for maintenance of normal epithelial cell differentiation at these sites. Since carcinogenesis may be regarded as a disease characterized by abnormal cell differentiation, it seems reason-

able to expect that agents that function to enhance normal cell differentiation might influence the process of carcinogenesis. The use of natural retinoids (retinyl esters, etc.) in the prevention of cancer is limited because of the following: (a) they may not reach potential target sites in adequate concentrations because of special mechanisms of their storage in the liver, and (b) ultimate excessive storage of retinyl esters in the liver may lead to severe damage to the organ. In view of the above, many new synthetic analogs of vitamin A (retinoids) have been made recently with the goal of developing agents that eventually might be useful in cancer prevention and are less toxic.

13-cis-retinoic acid has been found to have a marked inhibitory effect on the development of both preneoplastic and neoplastic lesions of the bladder epithelium induced by the carcinogen N-butyl- (4-hydroxybutyl) nitrosamine and N-methyl-N-nitrosourea in rats even when 13-cis-retinoic acid administration was begun after completion of the carcinogen treatment.

The effect of retinoids in the prevention of breast cancer has been equally promising. Retinyl acetate has been shown to have inhibitory effect on mammary carcinogenesis induced by 7, 12-dimethylbenz (a) anthracene

(DMBA) in rats. However, the synthetic analog retinyl methyl ether was chosen because of its higher tissue specificity for the mammary gland and lower toxicity as compared to retinyl acetate. It may be emphasized that in both studies on bladder and mammary cancer the retinoids were fed at levels that did not cause any observable toxicity or weight loss. Retinoic acid and its analogs have been reported to inhibit skin tumor promotion induced by 12-O-tetradecanoyl phorbol-13-acetate (TPA) and inhibited both TPA induced ornithine decarboxylase activity and formation of skin papillomas.

Retinoids, structural analogs of vitamin A, represent a new class of compounds with remarkable prophylactic and therapeutic activities in oncology and dermatology. It remains to the organic chemists to design and synthesize further structural variations of retinoid skeleton that will be superior to compounds used today in the chemotherapy of cancer and to the biochemists in general and scientists working on vitamin A in particular to investigate and decipher the biochemical mechanism of action of vitamin A in cancer.

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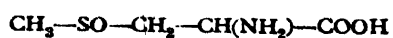
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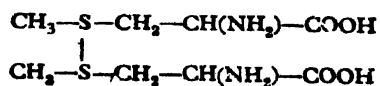


## Medicines from plants

THE medicinal value of plants depends on the presence in their tissues of chemical compound or compounds that have biological activity in men and animals. The active principles may accumulate in the storage organs, particularly in the roots or in seeds and sometimes in leaves, flowers, bark or other parts of the plants. So the impetus behind the study of medicinal plants lies on the biodynamic compounds which are present in their different tissues. There is no working principle which can tell us about plant products with certain specific predetermined kinds of activity. Generally the active principles are isolated empirically by practical research based on experience which have a limited validity. In this connection the folklore of plants may sometimes point out the type of pharmacological action; for example, the use of garlic and onion by common people for heart ailments. Recent chemical investigation has showed that garlic and onion oils contain S-methyl cysteine sulfoxide along with other sulfur containing substances. This compound has a prophylactic value in coronary heart diseases because *Escherichia coli* in the digestive tract converts this compound into dimethyl cystine disulfide which reduces cholesterol content of the blood.



I. S-Methyl cysteine  
sulfoxide



II. Dimethyl cysteine  
disulphide

A second example is *Catharanthus roseus* (*Vinca rosea*) which is known as a folk medicine in the treatment of diabetes in

India. It is used as a vermifuge and for treatment of dysentery in Malagasy. Recent research has shown that the plant contains both monomeric and dimeric indole alkaloids having hypoglycemic (Vindoline), anticancer (Leurocristine) and other types of biological properties.

There are more than 300,000 species of higher plants of which only a

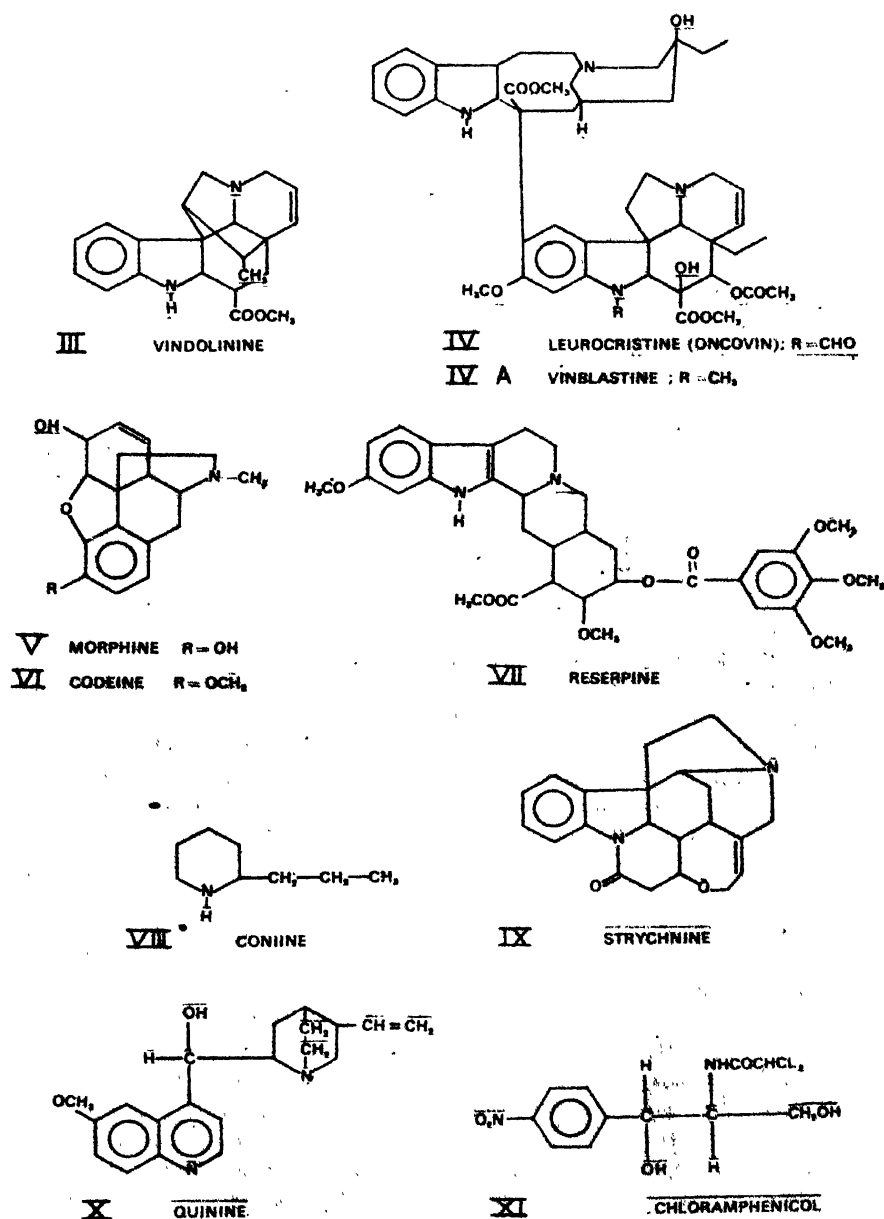


Fig. 1

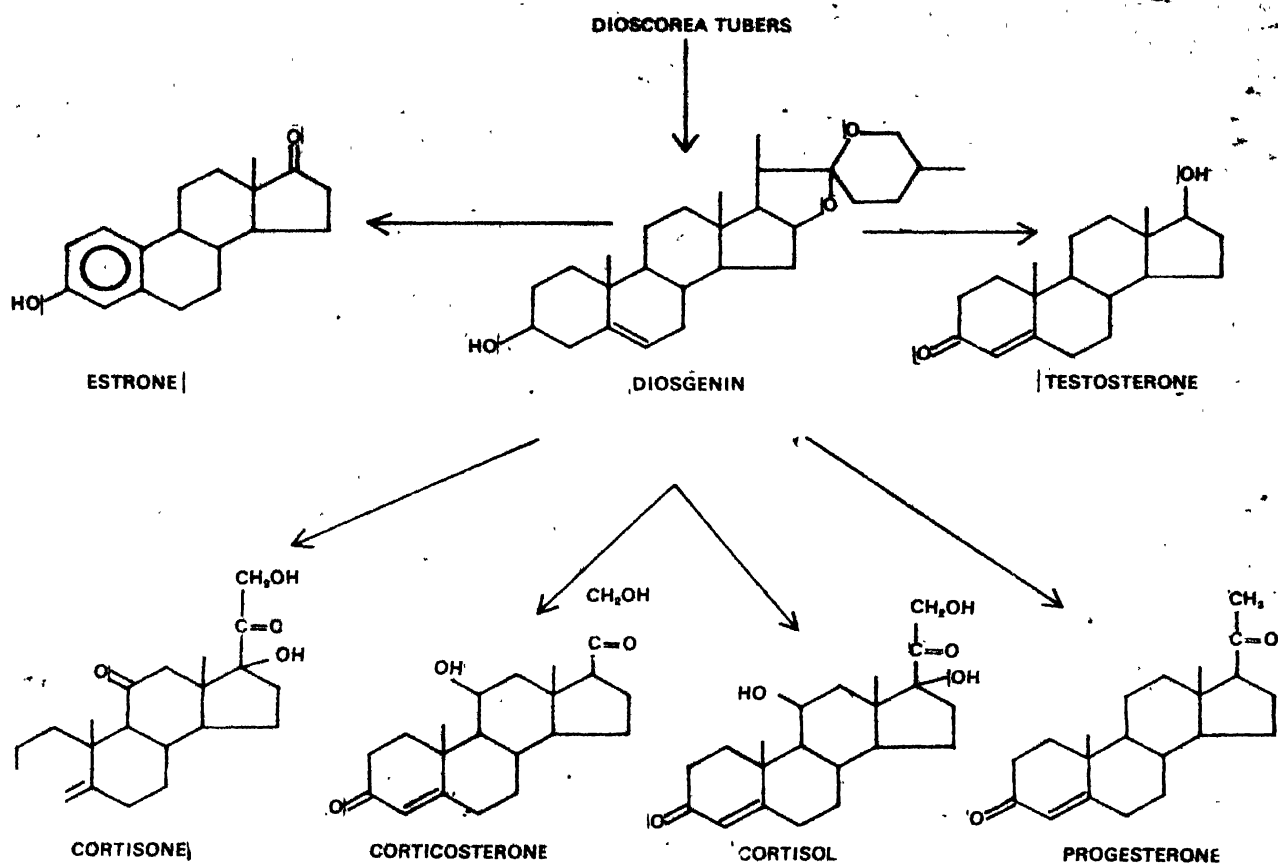


Fig. 2

small proportion has been investigated for medicinal properties, and a still smaller number yields well-defined drugs. Similar is the case with lower plants and with plants of the sea. So the knowledge of plant constituents gained so far is meagre considering the huge number of species available in the world. Approximately 10% of the organic constituents of plants are known and the remaining 90% are yet to be explored.

The association of plants with healing, religious practices and witchcraft is of very early origin and even in the pre-animistic stage of religion when men were not civilised in the modern sense, reverence for trees or tree-spirit was of great importance. According to W. Robertson Smith (1885) the "totem" was the species of a plant which the primitive people

worshipped and used ceremoniously to ward off evil influence, i.e., diseases. Similar was the case with "mana" which was also regarded as very sacred and powerful spirit inhabiting in a plant or in an animal which was utilised to cure diseases either by eating or by wearing an amulet filled with leaves or a part of the plant.

In the early history of human cultures, the Sumerians and the Chinese as early as 4000 B. C. referred to poppy as 'joy plant'. Today we know that latex of poppy yields opium from which morphine, codeine, and as many as 25 useful alkaloids. Another interesting example from the old world is the snake root, *Rauwolfia*. It was mentioned in the *Vedas* dating about 2500 B. C. which has led to the discovery of reserpine and other hypotensive ingredients of the plant. However,

the botanical identity of *Soma*, the divine plant which was used by the Aryans of the Indus valley (2500 B.C.) to prepare an intoxicating beverage on religious and ceremonial occasions remains a mystery. Ayurvedic system of medicine which claims its origin from the *Vedas* was developed into an elaborate science as is evident from the *Charaka* and *Susruta Samhita* written not later than 1000 B.C. These two works give a detailed description of medicinal plants with their uses. The plants have been given specific names and are often grouped on the basis of their curative actions. Still older examples of the art of apothecary dealing with plant preparations are recorded in the Egyptian pharmacopia, *Ebers Papyrus* (Ca. 1552 B.C.). In the early Greek literature (400-300 B.C.) there are also

many references to the use of drugs of plant origin. For example, we know that Socrates was executed by giving him hemlock which contains coniine and other pyridine alkaloids having toxic properties. Both old and new world early cultures have left a valuable legacy of knowledge on the uses of medicinal plants.

The early users of plant drugs gathered a good deal of information about the form and habit of plants in general to distinguish them clearly from others, but their classifications were based mainly on the uses to which plants were put. The Greek surgeon Dioscorides (64-120 A. D.) and the Roman naturalist Galén (131-200 A.D.) classified drug plants on the basis of their active principles like essential oils, perfumes, condiments, etc. Early classification of plants thus proceeded in a rudimentary way until the 17th century when plant taxonomy came to have a modern look.

In the beginning of 19th century, development of organic chemistry made it possible for the isolation of active principles from crude drugs. Morphine was isolated by the German pharmacist F. W. Sertürner in 1806 which represented an important landmark in phytochemistry. It seems to us as one of the greatest physiological importance because Sertürner's discovery subsequently led to the isolation of strychnine by the French chemist, P. J. Pelletier in 1818 from the seeds of *Strychnos nux-vomica*; quinine by French chemist, J.B. Caventou in 1820 from the bark of *Cinchona* sp. and many alkaloids from other plants which are used in folk medicines. Moreover, these works greatly facilitated the development of structural chemistry of natural products which subsequently led to the replacement of many plant drugs by those of synthetic origin. Eventually in the early part of 20th century, there came a time when the importance and exclusiveness of synthetic chemistry was exalted to such a high position that the potentialities of plant products

were mostly ignored. But with the introduction of chromatographic method for the separation of carotenoids by L. Zechmeister (California Institute of Technology, U.S.A.) in 1930, and more importantly, the development of paper chromatography by the Nobel Laureates A. G. P. Martin and R. L. M. Synge (U.K.) in 1944, interest in phytochemistry was revived. Over the last 20 years, many powerful analytical techniques like chromatography; electrophoresis; I. R.; N.M.R.; mass and X-ray spectroscopy along with radioactive tracer technique have greatly widened the horizon of the natural product chemists. Consequently a wide variety of plant constituents starting from simple alkanes to complex polysaccharides including flavonoids, steroids, alkaloids, etc., have been isolated.

Antibiotics, which are derived from lower plants (microorganism), need special mention because of their great importance in chemotherapy. Application of newer techniques for cultivation of microorganisms coupled with organised screening programmes has led to the discovery of some sixty commercially important antibiotics including penicillins and tetracycline of which chloramphenicol is the only one which is made exclusively by organic synthesis nowadays. There is now a greater interest in drugs derived from plant kingdom which represents an inexhaustible reservoir

of new compounds of medicinal interest.

Plant chemotaxonomy involves mainly the examination of secondary metabolites which are regarded as byproducts of plant metabolism in contrast to simple bases, sugars and organic acids that constitute the building units for the growth of the plants. Botanically-related plants often contain structurally related secondary constituents which are expected to have similar physiological action. This principle with certain limitations is utilised as an aid to biological speculation. As an example, colchicine which is an antimetabolic agent, is found not only in 16 different species of *Colchicum* genus but also in other species of the genera of Liliaceae to which *Colchicum* belongs.

Currently, tissue culture technique for propagation of medicinal plants, in which the genetic stability is not lost, has been receiving increasing attention. An excellent example is the successful increase in the yield of diosgenin by E. J. Staba and B. Kaul (Minnesota State University, Minneapolis, U.S.A.) in *Dioscorea* species by cell culture.

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## ***Citrullus colocynthis*—an important desert plant**

**FAMILY** Cucurbitaceae is represented by *Cucumis*, *Trichosanthes*, *Citrullus*, *Momordica*, *Dactylandra*, *Corallocarpus*, *Blastinia*, *Coccinia*, *Ctenolepis*, *Melothria* and their species. So far as the genus

*Citrullus* is concerned, Chakravarty (1959) of Botanical Survey of India reported earlier two species namely *C. vulgaris* (cultivar) and *C. colocynthis* (wild) from India. Recently A. K. Singh and the author (1977) of

the Department of Botany, University of Jodhpur, have reported that *Citrullus* is very well represented by its four taxa, namely, *C. colocynthis* Schrad, *C. vulgaris* Schrad, *C. colocynthis* var. *tatumba*, Singh and *C. vulgaris* var. *fistulosus* Stewart in Rajasthan. All species are commonly found in Jodhpur, Barmer and Jaisalmer. Out of these species *C. colocynthis* Schrad is very important for its oil content, medicinal properties and its well adapted nature in desert.

It is a perennial trailing herb. Its leaf ranges from 6 cm-15 cm in length 5 cm-10 cm in breadth with narrow or very narrow lobes. Greenish yellow flowers have acute spoon shape 5 cm  $\times$  9 cm corolla (Fig. 1). Fruit size is globose and 15 cm-20 cm in diameter. The colour of fruit turns pale yellow on ripening. Its pulp is spongy white in colour and bitter in taste. Seeds are narrow with a blunt end and brown in colour.

Amino acids from ripe and unripe fruits have been reported by R. Bhatnagar and his coworkers (1976) of the Department of Chemistry, University of Jodhpur. Compounds which have been extracted from fruit show some medicinal properties.

#### Proteins and amino acids

Protein percentage in ripe seeds varies from 24.5%-25.6%, but percentage of protein was comparatively

lower, i.e., 15% in unripe seeds. In pulp its percentage varies from 16%-17%. Unripe seeds contain glutamic acid, histidine and valine while only valine is present in ripe seeds. In fruit pulp arginine is present.

#### Medicinal properties

Coloside A, a glucoside, which has been isolated from the pulp of this plant shows antihistaminic and antiacetyl choline-like activities on

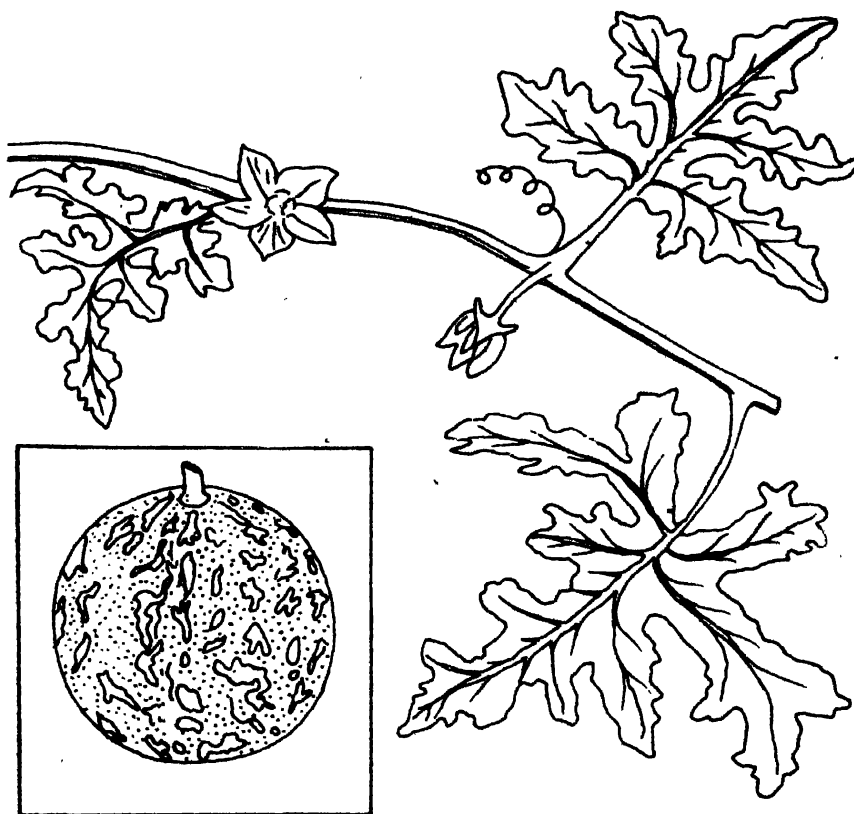


Fig. 1. *Citrullus* leaves; Inset : Fruit

Table 1. Total fat contents in different species of *Citrullus*

Name of species	Fat %			
	Old seeds		Fresh seeds	
	Range	Mean	Range	Mean
<i>C. colocynthis</i> Schrad	31.12-30.94	30.53	33.12-35.66	34.38
<i>C. colocynthis</i> var. <i>tatumba</i> Singh	18.25-23.24	23.24	19.86-26.88	23.37
<i>C. vulgaris</i> Schrad	10.70-21.1	15.55	12.35-23.6	17.99
<i>C. vulgaris</i> var. <i>fistulosus</i> Stewart	23.1-23.82	23.64	24.16-24.96	24.56

isolated rabbit intestine and guinea pig ileum. It also shows negative chronotropic and inotropic activity in isolated rabbit heart. Colocynthin has also been extracted from the plant. It has many medicinal values. It can be used as a drastic hydrogoque and as cathartic and diuretic in moderate dosages. In large dosages, it is emetic. It is an expectorant and alterative when taken in a small dose. Colocynthin is extremely bitter and has a purgative action.

#### Fat contents

Singh and the author (1978) reported that fresh seeds have comparatively higher fat contents than old ones. Secondly, *C. colocynthis* has appreciably higher oil contents (Table 1). In fresh seeds, oil is 30.12%-35.6% with a mean of 34.38%. This amount is close to the oil contents of some of the conventional oil yielding plants like

mustard (35.42%) and safflower (37%).

*C. colocynthis* is a very common plant known as *Tumba* in the local dialect. It is well adapted to grow under high thermal load, water stress and intense illumination. Cultivation of this plant as an oil yielding plant may play an important role in the economy of desert zone. However, it is necessary to analyse the contents to identify individual fatty acids in its oil. If individual fatty acids of this plant are similar to those of mustard (*Brassica campestris*) or groundnut (*Arachis hypogea*), then it may become a substitute for other conventional oil seed-crops which do not grow well in desert.

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## Licking heals wounds faster

**I**F you get a wound, lick it immediately. It will make it heal faster. This is the finding of a team of doctors consisting of J. M. Hutson, M. Niall, D. Evans and R. Fowler of the Royal Children's Hospital in Melbourne, Australia, who studied wound healing process in mice (*Nature* 279, 793, 1979). They made a small cut in the skin at the centre of the back of a mouse so that it was unable to lick the cut itself. The wounds of mice were then observed for healing by caging the mice either alone (no licking) or in small groups (licking). The size of the wound measured on alternate days. The grouped mice, which licked each other's wound, healed much faster than those which were caged singly. This suggested that there was something in licking which enhanced healing process of the

wound. The authors thought that the salivary glands might be involved. So, they removed the salivary glands from a group of mice and compared them with normal, intact group. The wounds of the group whose sublingual and submaxillary glands were removed,

healed much slowly as compared to the sham-operated controls and the slow healing was similar to that observed in normal animals caged singly. When submaxillary glands were removed alone, the healing of wounds was slower than in the sham-operated controls. Thus the result implied that the sublingual glands as well as the submaxillary glands contained an active substance that affects wound healing. It was also observed that the parotid glands had no significant role in the healing process.

Further to examine the possibility that the healing effect may be mediated by both exocrine and endocrine routes, they performed the experiments with mice whose gland-duct were ligated. This showed that the wound healing was faster in gland-duct ligated mice than in the sialectomised mice, suggesting that the saliva was necessary for rapid healing.

Although the authors do not know what promotes faster healing, they do believe that it is from the mouse submaxillary and sublingual salivary glands, applied by saliva through licking and not in the parotid glands. The isolation of this factor from the glands could be of practical importance in human surgery as the healing process is believed to be similar in all mammals.

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## Some interesting facts about horse's vision

**T**HE horse's eyes have certain characteristic features which make them function differently from other animals. If you understand the horse's eyes, you may better appreciate the

way he behaves. The eyes set of horse has been placed on the sides of his head. This arrangement imparts monocular side vision to the animal, i. e., he is able to see things on his

both sides at the same time. He can see almost entirely to his rear. The only space he is unable to see is the space blocked by the width of his own body. Thus nature has gifted him with a side and rear vision.

The horse has to exercise full concentration in focussing on the objects directly in front of him to get binocular vision of the objects. When he has done so, he is virtually blind in other directions. Since the eyes are unable to focus at a distance less than about 1.20 m, it is said that horses cannot see what they are eating. The practice of using 'Blinders' on the horses's eyes used in transportation has been evolved so as to make it easier for them to concentrate forward and use their binocular vision. By doing so a horse is totally blocked out from what is going on his sides and at the rear. Blinders are still used in race horses so that animal's attention is only concentrated to where he is going. The horse required to jump over high obstacle jumps blindly because at the final moment of taking flight, the horse cannot see the ground nor the obstacle before him due to his inability to focus at a distance less than 1.20 m.

Another limitation of horse's vision is that he cannot see the objects clearly which are above the level of his eyes. The construction of horse's eyes prevents him from seeing details of distant objects as we do. Moreover, a horse is colour blind.

To overcome these vision defects, horse makes use of their flexible neck. The horse is capable of changing focal length for his eyes with the change in position of his head. If he raises his head, he can see things better at a greater distance and with lowering of head, close up objects get sharper. The best forward focus comes when the horse puts his face perpendicular to the ground. At this position he sees very little of the sides. Therefore, a horse going to jump over an obstacle should be helped by letting him choose his over head and neck position for best possible vision. The

ability of the horse to adjust focal length of eye by head position is made possible due to shape of retina (viewing mirror at the back of eye ball) which is flattened in horse's eye in contrast to other animals who possess nicely curved retina which gives a sharp image. In addition, the lens and cornea of the horse are not properly shaped. They are somewhat like a scratched camera lens with irregularities on its surface which will not allow

a sharp vision. Nowadays experts believe that horses who see the best in front of them are the smartest. Frontal vision is best in those horses whose eyes are more centrally located on either side of rather narrow forehead.

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## Breeding strategies of ostriches

**T**HE ostrich (*Struthio camelus*) is the largest of living birds. Adult males stand about 2.5 m tall and weigh more than 135 kg; the females are slightly smaller. Only a few decades ago, ostriches ranged from the Arabian and the Saharan deserts southward throughout Africa. The last ostrich in Saudi Arabia was shot and eaten in 1944. Today they are mainly found in central Africa, especially in the teeming national parks and sanctuaries of Tanzania, Kenya, Uganda, Somalia and Zambia.

Ostriches live in open, dry country in loose bands of 5 to 15 birds. They show a sort of symbiosis with zebra, wildebeest, gazelle and antelopes. These heavy browsing herbivores stir up insects, lizards and rodents which the ostriches relish. In return, the birds, with their long necks, spot approaching danger and alarm the herbivores.

The flightless ostrich obviously nests on the ground. Though the ostrich lays the largest egg of any living bird, but oddly enough the egg is one of the smallest in relation to the size of the bird. The hard-shelled egg is white to yellowish in colour and the shiny surface is ornamented by superficial pores of different sizes and shapes.

Like other ground-nesting birds, elaborate arrangements for the nest are not made. The female ostrich scrapes out a large depression on the ground in which she lays 10-12 eggs. Sometimes upto 30 eggs or more are found in one nest—the result of several females laying communally. Due to large size of the egg and hard shell, the ostriches can afford to lay only on alternate days.

The ostriches are extremely alert and wary birds, so, until recently it was almost impossible to study them in the wild. Incomplete and inaccurate observations led to many mistaken beliefs about them. For example, one of the popular legends is that ostriches bury their heads when danger threatens. In the early 1960's, a husband and wife team of zoologists, the Sauers (*The Living Birds*, 5, pp. 45-75), extensively studied these birds in South West Africa by ingeniously disguising their blind in the form of a termite mound. Soon the bewildered birds became accustomed to the 'mobile' mound and the two zoologists made some remarkable discoveries about the social life of ostriches.

Concentrating his studies on the Masai Ostrich (*Struthio camelus massaicus*), recently Brian C. R.

Bertram of the King's College, Cambridge, U. K. found that unlike many polygamous birds, male ostriches do not form 'harem'. Other females just live in the vicinity of a pair (personal communication). The adult sex-ratio is biased, with 1.44 females per male. Depending upon their status, the females are categorized as 'major hen' or 'minor hen'. A major hen initiates nest-making and with the male does all the incubation. Cryptically-coloured female sits on the eggs during daytime, while the dark male incubates in night. The minor hens, which drift from territory to territory, promiscuously mate with different males and lay their eggs in different nests. However, major hens soon push many eggs of minor hen(s) into a surrounding ring, 1-2 m away, leaving 18-25 eggs together in a central group. Only the central eggs are incubated.

Uptill now, it was widely believed that the most advanced eggs (in development) are pushed out beside the nest to synchronize hatching. However, Bertram (personal communication) has found that "eggs are rolled out at the start of incubation". Through meticulous studies of the surface texture, relative size, shape and colour, Bertram (*Nature*, 279 : 233-234, 1979) found that the major hens avoid pushing out their own eggs. Nevertheless, all eggs of minor hens are not pushed out of the nest. In one nest, 9 out of 19 eggs belonged to major hen, but all the 9 eggs in outer, unsuccessful ring belonged to minor hens.

Now the question arises, why the major hen rolls out minor hens' eggs. The answer is complex and could be provided by detailed studies of the behaviour of the species.

It is to be noted that for successful incubation and rearing of chicks both the female and male ostriches are required. Unlike other polygamous

birds, for example, peacocks, certain pheasants, etc., female ostrich alone is incapable of rearing the brood. In spite of this fact, there is always preponderance of females, thus, a few females (i.e., minor hens) remain unpaired but not unmated, thanks to the promiscuous nature of the male. Now if these minor hens make their own nests there will be hardly any chance of the survival of nests in absence of the attending males. There are two options left for them : either two or three minor hens can nest and incubate communally, or, they can dissipate their eggs in the well-guarded major hens' nests. They cannot choose the first option because female ostriches have a tendency to sit on the eggs only during daytime. In these collectively nesting minor hens, the eggs will be well guarded during day but neglected during night. Therefore, the minor hens choose the second option and lay their eggs in major females' nests. Even though the major hen pushes out some "foreign" eggs but still many eggs of minor hens are left to be successfully raised.

Moreover, the major hens also derive certain advantages by the presence of "foreign" eggs. It is because the minor hens' eggs dilute and buffer the major hen's eggs : if a predator removes one egg, it is less likely to be one of her own. Bertram in a paper presented in the 17th International Ornithological Congress, held in West Berlin in 1978, reported that the predators do not always destroy the whole nest—91 per cent of surviving nests had one or more of their eggs destroyed. Therefore, the larger the number and larger the mixture of eggs, the less likelihood of destruction of major hen's eggs.

The second factor is the relative size of the egg in comparison to the body : ostrich eggs are only 1.5 per cent of adult bird's body weight. However, due to the thickness of the

shell, the body could not mobilize necessary calcium for daily laying of eggs, as a result of which ostriches lay relatively small eggs (in comparison of body) and that also only on alternate days. Now, if they lay 20 to 25 eggs (their normal incubation capacity), it will take at least 40-50 days to lay the eggs. The longer the nesting period the more the parental troubles and chances of nest destruction. Therefore, it does not cost her (the major hen) a loss in fitness to incubate extra eggs of other birds (the minor hen's).

So the ostriches have unique breeding strategies. For successful hatching and rearing, both male and female birds are required but in nature females are always in a larger number. Though a male ostrich mates promiscuously with females, he devotedly lives with his favourite female. ( i.e., the major hen). The mated but unpaired minor hens lay their eggs in a major hen's nest which is well-guarded by the male ostrich. They have the satisfaction that at least a few of them will be successfully hatched and reared. The major hen has two advantages; (1) she keeps a few of the minor hens' eggs as a buffer stock to protect her own eggs, and (2) she incubates a few eggs of minor hen(s) and thus completes her nest according to her brooding capacity. In this way, she makes up for the loss of eggs due to her physiological handicaps.

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SCIENCE REPORTER

## From garden to medicine chest— the Madagascar periwinkle

THE study of plants as a source of food is one of the oldest human activities. From earliest times, man had to distinguish between plants which were poisonous and those which were not and he gradually acquired knowledge about drug yielding plants. Thus began the era of medicinal plants. A probe into the plant kingdom in pursuit of a treatment for cancer has brought to light the Madagascar periwinkle, which has potential anticancer agents.

Madagascar periwinkle (*Catharanthus roseus* G. Don) is an attractive plant with pink and white flowers (Fig. 1). It was introduced into the gardens of India from Madagascar as an ornamental plant. The original home

of this plant being Madagascar, it is often called Madagascar periwinkle. It is variously designated by different local names, viz., Baramassi (Hindi); Nityapushpa, Kasikanagale (Kannada).

Periwinkle has a long history behind it. The use of this plant as medicine can be dated back to 50th century B.C. The folk medicine literature of Europe makes a mention of this plant as diuretic (enhancing urine flow), antidysetric, haemorrhagic (preventing excessive blood flow from wounds) and wound healing. In the folklores of India and Jamaica this plant enjoys a reputation of curing diabetes. The natives of these countries have a strong belief that the 'tea' prepared from the dry leaves of this

plant can cure diabetes. The leaves are also used in South Africa, Australia, South Vietnam, Philippines and in England. In South Africa and England proprietary preparations are available called 'Covinca' and 'Vinculin' respectively. They are nothing but leaf infusions of *Catharanthus*.

The folklore mention of this plant as anti-diabetic attracted the Canadian scientists Noble, Beer and Cutts (1958). With an intention of bringing this into modern medicine, they tried the aqueous extracts of the leaves of this plant on diabetic rabbits. They found that it had no effect on reducing blood sugar level. They did not stop at this stage but injected the aqueous extracts into rabbits by the intravenous route. To their astonishment the animals were affected in an unexpected manner. The rabbits died following an injection within 5 to 7 days.

Investigating into the cause of the death, they found that it was due to septicaemia (a condition wherein the



Fig. 1. *Catharanthus roseus*



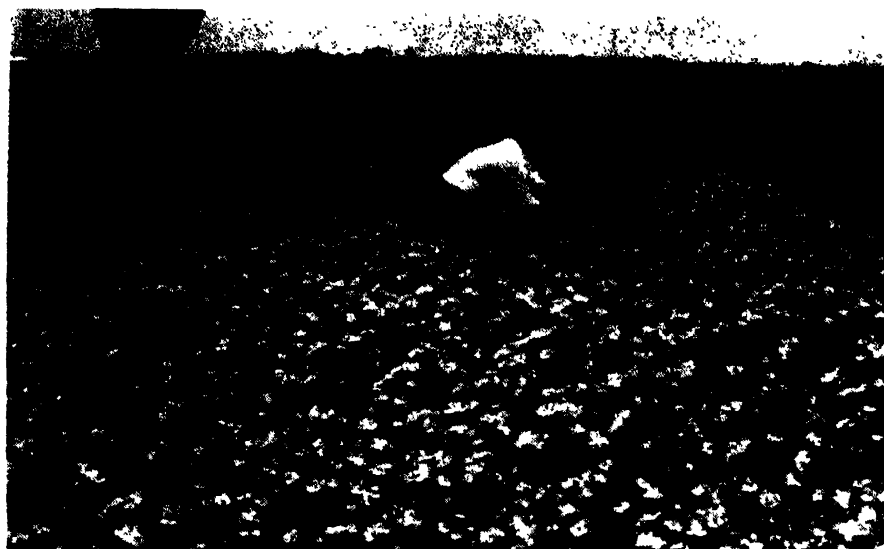


Fig. 2. A student working on *Catharanthus roseus* at University of Agricultural Sciences, Bangalore

disease organisms attack due to the failure of body immune system). Liver and kidneys were attacked by bacteria. On culture, *Pseudomonas* (bacteria) were constantly found. As these organisms were not seen in the extract injected into rabbits, the scientists concluded that it was an internal infection. Continuing their investigations, they established that *Catharanthus roseus* extract has a definite effect on white blood corpuscles. The extract as injection was capable of bringing down the white blood corpuscles in the blood. After this discovery by the Canadian scientists it was concluded that rabbits' death followed the failure of body immune system. The reduction of white blood corpuscles reduced the immunity of the body to the pathogens and paved the way for *Pseudomonas* (bacteria) attack. That is how rabbits died due to septicaemia.

The unexpected death of rabbits provided new hope for treating blood cancer (leukemia). In case of Leukemia patients, there will be increased bone marrow activity leading to an increase in the white blood corpuscles in the blood. From their earlier experiments on rabbits, the

scientists had found out that the leaf extract reduced white blood corpuscles of the blood. This prompted them to try the extract on leukemia patients. They found that water extract of 2 grams of dried leaves of this plant caused a reduction in white blood corpuscles to below 10,000 in 3 to 4 days. They decided to attempt a chemical purification of the extract and this led to the isolation of Vincalukoblastine—an active anticancer drug. Svoboda, tested the periwinkle extracts in Eli-Lilly Research Laboratories (Indiana, USA) and confirmed that the extract is useful against acute leukemia.

The other two important alkaloidal drugs found in this plant are the Reserpine and Ajmalicine. Earlier, the important source of reserpine was *Rauwolfia serpentina* (Sarpagandha). Reserpine, by acting on the central nervous system, is capable of bringing down the high blood pressure (hypertension). For the manufacture of this important drug American pharmaceutical companies used to import the *Rauwolfia* roots from India. To their surprise, they found in one lot a higher content of reserpine. Investigating into this they found that the roots of

*Rauwolfia* were mixed with *C. roseus* roots. This adulteration was mainly responsible for the discovery of reserpine in the roots of *Catharanthus roseus*.

The above two incidences emphasise that chance discoveries are still made in science.

These discoveries have contributed much to the medical field in general and to cancer therapy in particular. Two of the alkaloids present in the leaves of this plant are presently available as prescription drugs. They are Vincalukoblastine and Vincristine.

Vincalukoblastine is available in its sulphated form. Hence it is called vinblastine sulphate. It is unstable and hence available in the sealed ampoules which should be stored in refrigerators to assure extended stability. This is used in the treatment of a wide variety of cancers and is recommended for Hodgkin's disease (cancer of lymph glands). It should be administered intravenously in doses regulated by the patient's age, body weight and white blood cells in the blood. The usual dose is 100 micrograms per kg of body weight. Each succeeding dose should be increased by 50 micrograms per kg of body weight once a week. It is available under the trade name of Velban.

Vincristine sulphate is also unstable and refrigerated storage is inevitable. It is recommended against leukemia in children. The dosage is 50 microgram per kg of body weight, initially, each succeeding dose increased by 25 micrograms per kg of body weight until optimum therapeutic benefit is seen. Its trade name is Oncovin.

In addition to curing blood cancer, cancer of lymph glands and high blood pressure, *Catharanthus* alkaloids are also known to have antimalarial, antihelminthic, anidiuretic, antibacterial and antifertility activity. Though contradicting to the work of Noble, Beer

and Cutts, it is interesting to note that Asthana and others from Regional Research Laboratory, Jammu Tawi, have reported antidiabetic activity of this plant. They may isolate the active ingredient and provide a sub-

stitute for oral insulin.

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## Pesticides degrading plasmids

**M**ICRO-organisms play a central role in the degradation and recycling of all naturally synthesized organic molecules. Without the activity of microbes such organic compounds would accumulate and pollute our environment. Since World War I a vast array of synthetic organic compounds have been introduced for use in agriculture as insecticides, weedicides, rodenticides, fungicides, etc., where they are essential for continued productivity. Use of synthetic pesticides which appear to have no counter-parts in nature, pose a challenge to the natural degradative processes of micro-organisms. Whether a pesticide persists or is degraded as in many cases depends upon microbial processes. Hence, development of such microscopic species which can degrade the nonbiodegradable pesticides or accelerate the process of degradation of some highly persistent pesticides can solve to a great extent the environmental problem arising due to continued use of these compounds.

Recently two Australian scientists have discovered the role of specific plasmids which can readily degrade the compounds of phenoxy acetic acid group. Excepting the recalcitrant pesticide 2, 4, 5-T of this group all other compounds such as phenoxy acetic acid (PAA), 2-methyl, 4-chlorophenoxy acetic acid (MCPA) and 2, 4-dichlorophenoxy acetic acid 1, 2, 4-D have been found to be degraded by a bacteria *Alcaligenes paradoxus*. They

have observed that certain bacteria cells contain plasmids conferring the ability to degrade the naturally occurring molecule PAA (phenoxy acetic acid). After the application of 2,4-D for agricultural purposes these organisms come in contact with new but identical molecules. The exposure, thus results in the selection of cells in which the plasmids have evolved the ability to degrade 2,4-D. This evolutionary process involves two courses. First, the plasmid *paa* gene is duplicated. Second, one copy of the *paa* gene mutates to become a *tdf* gene which is capable of degrading 2,4-D. The advantage of this evolutionary process is evident from the fact that bacterial cells evolve the ability to degrade the synthetic molecule 2,4-D and at the same time retain the ability to degrade the naturally occurring molecule PAA.

The 2,4-D degrading bacteria carry the bulk of their genetic determinants on a single, large, circular chromosome which is also called plasmid. These plasmids are transmissible from one bacterial cell to another by a process known as conjugation. During the conjugal process, the cell possessing the transmissible plasmid (the donor) produces a conjugal tube which attaches to a second cell which lacks the plasmid (recipient). The donor cell makes two identical copies of the plasmid. One plasmid copy is retained by the donor while the second is transferred rapidly to the recipient cell

via the conjugal tube. Thus, the plasmid and the genetic information it carries can be transferred rapidly to a population of bacterial cells which originally did not possess it.

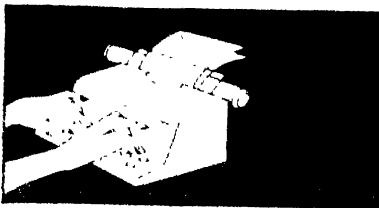
Rapid evolution and spread of 2,4-D plasmid in response to the environmental use of 2,4-D prevents any possible environmental pollution by this chemical and structurally related synthetic pesticide MCPA. If the 2,4-D degrading plasmid is a pointer, similar other genes capable of degrading a wide range of highly persistent pesticides such as organochlorines can be evolved. Originally, the plasmid theory has been associated with the depleting efficacy of antibiotics due to development of resistance among bacteria, but its application in the field of environmental science may be helpful in providing effective measures to combat the pollutional hazards caused by the use of toxic chemicals in agriculture and public health.

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## Biofertilizers

**N**ITROGEN is a free commodity in the atmosphere. A positive balance of usable nitrogen on the earth depends upon nitrogen fixation which is the process by which atmospheric nitrogen,  $N_2$ , is converted either by biological or chemical means to a form of nitrogen, such as ammonia,  $NH_3$ , that can be used by plants and other biological agents. In biological nitrogen fixation micro-organisms, either free-living or in symbiosis with plants (mainly in root nodules), reduce  $N_2$  to  $NH_3$  at atmospheric pressure and

(Continued on page 424)



## NEWS & NOTES

### Interview

### K. Chattopadhyay

**"TRY** to give a young boy a glimpse of the treasure and beauty that is science, the rest will come naturally. I was encouraged to take up science the same way," says Dr Kamanio Chattopadhyay, the winner of Indian National Science Academy (INSA)'s Young Scientist Medal 1979 in engineering sciences. Dr Chattopadhyay further adds that he received in plenty the encouragement to take up science from all quarters—family, friends and teachers. In fact, science research as a career was "the most natural thing" for him to take in the environment he was brought up. Few Indian scientists can boast of such a happy beginning in science.

Dr Chattopadhyay, who is presently a lecturer in metallurgical engineering in Banaras Hindu University, definitely enjoys science and his research on materials. "You try to understand materials step by step, system by system," he replied to one of my questions, "and at the same time try to find out a unifying picture, which will give you the predictive power useful for a technological design". He says that each small step is important and hard labour accompanied with rational thinking is the key in research. He always finds, he adds, the research problem he is tackling

at the moment the most exciting challenge.

Born on March 3, 1950 at Khanda, Madhya Pradesh, Dr. Chattopadhyay belongs to a highly educated family. After passing B.E. from Regional Engineering College, Durgapur, he did M.Sc. in metallurgical engineering and Ph.D. from Banaras Hindu University. Throughout his career, he stood first in his class and even received the University Gold Medal in 1973 when he passed M.Sc. He bagged the INSA medal for his researches on rapid solidification of metals and alloys.

"When metals or alloys are solidified at a rate of more than million degrees per second, they often undergo structural changes leading to new kinds of material. These changes include formation of new crystalline phases having different atomic arrangements and formations of metallic glass having completely disordered atomic arrangements. They are a new kind of materials and often exhibit properties not easily attainable in normal materials. For example, a metal glass may have very high strength and corrosion resistance while it retains most of the metallic properties." Dr Chattopadhyay's researches concern developing suitable production processes and trying to understand these products through electron microscopy.



Dr. Chattopadhyay

Commenting on research in India, Dr. Chattopadhyay says that our scientists are really doing a good work considering the prevailing environment, both mental and infrastructural. He however adds that the standard of research varies too much and so the average is not so bright. "Our scientists," he adds emphatically, "mostly do extension work rather than tackling problems at the emerging frontiers. A particular kind of science culture, which promotes daring, unconventional and yet rational course in research, is mostly missing in the world of Indian research".

DILIP M SALWI

## Symposium on Small Craft

**THE** Research & Development Establishment (Engrs) of the Defence Research & Development Organisation, Ministry of Defence, proposes to conduct a symposium on Small Craft at Pune in February 1981. The object of the symposium is to provide a forum for coming together of academicians, naval architects, struc-

tural engineers, material technologists and boat builders to discuss the technical aspects of the various problems faced by them and to arrive at mutually beneficial conclusions. This will also help in promoting advancement of marine technology as applied to small crafts

All types of small boats and me-

dium-sized landing craft used in rivers, canals and sheltered water creeks are proposed to be covered in the symposium. The papers will be generally grouped under following heads : Materials of construction; Design considerations with special reference to the evaluation of resistance; Fabrication techniques and practices; Propulsion and navigation systems; Inspection procedure and quality assurance.

Special guest lectures by eminent persons in the field will also be arranged.

In addition to the symposium, an exhibition of small craft will also

be arranged. All boat manufacturers are requested to display their products so as to popularise them.

The registration fee for individual delegates is Rs. 125/- whereas the fee for Industrial/Institutional registration is Rs. 200/-. The last date for receipt of intimation for submission of papers is 15 August 1980.

Those interested in taking part in the symposium may contact :

LT. COL. R. G. WASTRAD, ENGRS.

Convener

Symposium on 'Small Craft'

R & D E (Engrs)

Dighi, Pune 411015

and COMPENDEX for Indian scientists. These data bases include bibliographical information pertaining to chemistry, chemical engineering, technology, physics, computers and control and all branches of engineering. The information is useful for keeping track of current developments in these specialities. Scientists engaged in teaching, research, product development and production oriented activities will be benefited by utilising the service. This current information is searched by means of most modern computers on individual basis, group basis and product basis. The service will be made available once in a month from INSPEC and COMPENDEX twice a month from CA Search. With a view for maximising benefits to the Indian scientists, INSDOC will be conducting a series of training courses for librarians and information personnel engaged in the institutions using the computer-based SDI Service. It is also planning to conduct a day's exposition on SDI Services for the practising scientists and engineers. Further details about the SDI Service and these courses and seminars can be had from Shri A. Krishnan, Scientist-in-Charge, INSDOC, Hillside Road, New Delhi-110012.

### Conference

## Nuclear track detectors

**E**LEVENTH International Conference on Solid State Nuclear Track Detectors will be held from 7-12 Sept. 1981 at the the University of Bristol, England. Further details can be had from Professor P. H. Fowler, H. H. Wills Physics Laboratory, Tundall Avenue, Bristol BS8 1TL, England.

## Utilization of animal resources in Orissa

**A** symposium on "Utilisation of Animal Resources of Orissa" was held in the P. G. Department of Zoology, Utkal University, Bhubaneswar on the 22nd and 23rd March 1980 under the joint sponsorship of the Post-Graduate Department of Zoology, Zoological Society of Orissa and Orissa Association for Advancement of Science. Prof. B. K. Behura presided over the sessions on both days. In total 20 abstracts were accepted and out of these, 14 papers had been presented.

In his presidential remarks Prof. Behura stressed on the need of a Snake Park in Orissa. He also described that Cantharidin is extracted from some species of beetle of the families Meloidae of which *Mylabris Pustulata* is

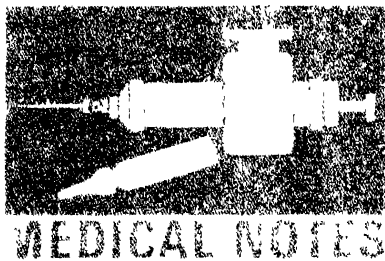
quite common in Orissa. Papers dealing with crocodile projects and utilisation of tasar silk resources of Orissa were prescribed. Utilisation of amphibians for food, and pest control and insects for detection of crime were dealt with.

P. M. Hejmadi added some points on frog-culture and said that it was difficult to promote good thigh development in frogs. In Japan this process is enhanced due to its correlation with the silk industry in which waste cocoons serve as food to frogs.

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## Computerised information for scientists

**I**NSDOC announces a regular computer-based SDI Service from the commercially available data bases, such as CA Search, INSPEC



## Human influenza —evolution of pandemic strains

**H**UMAN influenza is of global concern for the public as well as to medical and public health authorities. As many as 20 million people died due to this malady all over the world in the pandemic of 1918. It is an acute, highly infectious, communicable respiratory illness caused by one of the influenza virus. The disease, which is characterized by an abrupt onset of short duration respiratory involvement, often occurs as epidemics (involving vast area or country) or as pandemics (involving several countries or the entire globe). It spreads rapidly with high attack rate but has low mortality. The manifestations consist of fever, chills, headache and generalized muscular pains. Sometimes a sore throat is followed by hoarseness, nasal obstruction, nasal discharge, sneezing and cough. Deaths as a result of viral pneumonia are rare. However, superinfection due to bacterial agents in very young and old age groups, or in those debilitated by chronic pulmonary or cardiac disease may prove dangerous.

The causal agent of influenza is a single-stranded RNA virus of helical symmetry (Fig. 1). The infectious virus particle is spherical in shape, 80nm-120 nm in diameter and packed in a lipoprotein envelope. Filamentous forms of virus are also seen. The influenza virus is classified under

'myxoviruses', which means a virus having affinity for mucoprotein (glycoprotein) substance. These viruses are able to adsorb to red blood cell's (RBC) mucoprotein receptors and to elute (dissociate) from them subsequently, i.e., haemagglutination followed by spontaneous elution. The elution is accomplished by the destruction of RBC receptors by a viral enzyme, neuraminidase. The property of viral haemagglutination was discovered for the first time by George K. Hirst at Public Health Research Institute of New York in 1941 by a chance rupture of a blood vessel while harvesting the allantoic fluid from influenza virus infected chick embryo. Influenza virus has been associated with several milestones in the development of medical virology. Isolation of the virus in ferrets by W. Smith, C.H. Andrews and P. P. Laidlaw in 1933 and subsequent pioneering work by Nobel Prize winner, F. M. Burnet of the Walter and Eliza Hall Institute of Medical Research Melbourne, Australia in 1940, by growing the virus in embryonated chicken eggs opened new vistas for the study of viruses.

There are three distinct immunogenic types of influenza virus, viz., A, B and C. The types are further subdivided into 'subtypes'. For example, type A virus has subtypes A<sub>0</sub>, A<sub>1</sub> and A<sub>2</sub>. The subtypes are differentiated into 'strains'. The A, B, C types are classified on the basis of their distinct soluble ribonucleoprotein (NP) antigens. The NP antigen is common to all the strains within a type. The

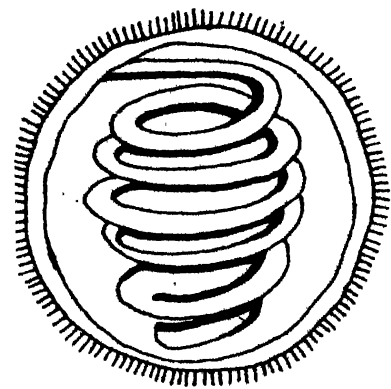


Fig. 1

subtypes and strains are differentiated on the basis of the haemagglutinin (HA) and the neuraminidase (NA) antigen types present on the envelope of the virus. The haemagglutinin is a rod-shaped glycoprotein polymer whereas the neuraminidase is a mushroom-shaped glycoprotein polymer (Fig. 2). Although all the three types infect man, only the type A virus is known to infect some of the animal species, viz., birds, horses and swine.

### Nomenclature of influenza viruses

The system of nomenclature currently in vogue is based on all the three major antigenic components, viz., NP, HA and NA antigens. The description includes following points:

(a) The antigenic type of ribonucleoprotein (Type A, B or C); (b) The place and animal species (in case of animal origin strains) from where

Table 1. Antigenic make-up of pandemic strains of influenza virus

Year of Pandemic	Designation of strain		Association of pandemic with antigenic shift in	
	Previous	Current	HA	NA
1918-1919	A <sub>0</sub>	A/London/1/35 (H <sub>0</sub> N <sub>1</sub> )	+	—
1946	A <sub>1</sub>	A/FM/1/47 (H <sub>1</sub> N <sub>1</sub> )	+	—
1957	A <sub>2</sub>	A/Singapore/1/57 (H <sub>2</sub> N <sub>2</sub> )	+	+
1968	Hong Kong	A/Hong Kong/1/68 (H <sub>2</sub> N <sub>2</sub> )	+	—

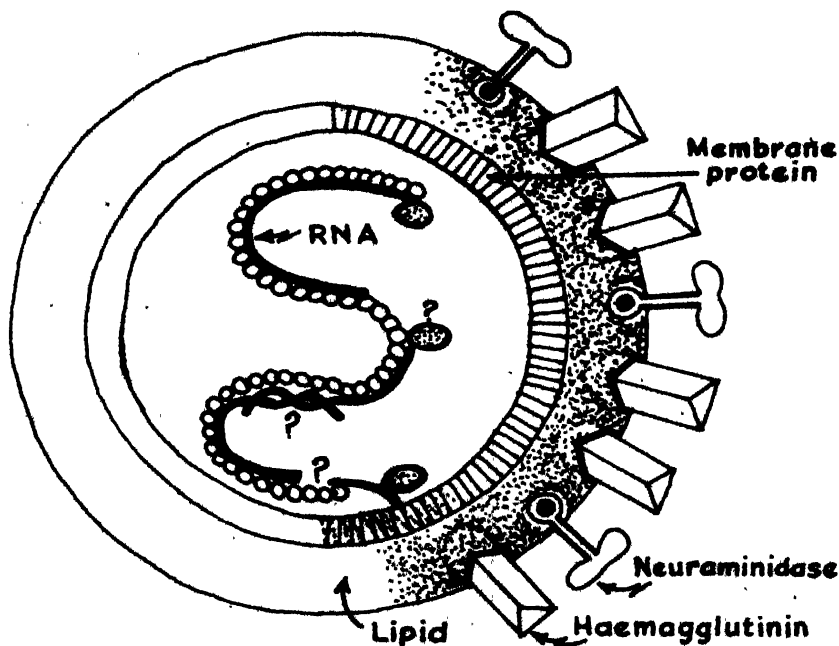


Fig. 2

isolated; (c) Strain number; (d) Year of isolation, and (e) A description of the HA and NA antigens.

Following are some of the examples:

- (i) A/Hong Kong/1/68 ( $H_3N_2$ ),
- (ii) A/Singapore/1/57 ( $H_2N_2$ ),
- (iii) A/Turkey/Wisconsin/1/66 (Hav 5  $N_2$ ), and
- (iv) A/Swine/Taiwan/1/70 ( $H_3N_2$ ).

Thus, the major influenza pandemic which arose in Hong Kong in 1968 is designated A/Hong Kong/1/68 ( $H_3N_2$ ) to denote the type, A; the location, Hong Kong; the isolate number; and the year, 1968. The bracketed letters and numbers indicate that only its HA, but not NA, antigen was distinctly different from that of the earlier subtype recovered from Singapore during 1957 pandemic, A/Singapore/1/57 ( $H_2N_2$ ).

#### Antigenic variation and pandemics

Major changes in HA or NA or both antigens ( $H_2$  to  $N_2$  or  $N_1$  to  $N_2$ ) are known as 'antigenic shift'. On the other hand, minor antigenic variations within a particular HA or NA antigen

are referred to as 'antigenic drift'. The epidemics of influenza occurring every 1 to 3 years are attributed to the antigenic drift on account of minor changes in the envelope antigens of the virus. The pandemics which occur at longer intervals are due to antigenic shift. The world has experienced four major influenza pandemics during 1889-1890, 1918-1919, 1957-1958, and the latest in 1968-1969. Evolution of these pandemics as a result of antigenic shift has been given in Table 1.

As is evident from Table 1, the pandemics of 1946 and 1968 were due to antigenic shift occurring in HA antigen whereas the 1957 pandemic involved antigenic shift in both HA and NA antigens. It has been postulated that large changes in the HA antigen in 1946 and in 1968 were due to genetic recombination (reassortment) between human and animal influenza viruses. The  $A_2$  subtype of 1957 pandemic differed not only in HA and NA antigens from all previous strains but also in many other characters. Origin of such a virus was considered to be from

extrahuman source due to recombination, i.e., sharing of genetic material between human and animal strains. It is now known that animal strains of influenza A occur in many animal species including swine, horse and several avian species, viz., chicken, turkey and duck. Experimental infection of animals with two different influenza virus strains has shown that recombination is possible in dual infection. Due to the possibility of cross-infection of type A viruses of man and animals, the latter are considered as the natural factories for the production of new recombinants capable of causing new pandemics. This very fact not only puts influenza under zoonoses (diseases transferable between man and animals) but also emphasizes the role of animal influenza strains in evolving new pandemic strains from time to time.

#### Inter relationship between animal and human influenza viruses

The first evidence for interrelationship between animal and human influenza virus was demonstrated by a veterinarian, J. S. Koen of Fort Dodge, Iowa in 1919 when an outbreak of influenza in swine was reported just after 1918 pandemic. It is now believed that the human strain of 1918 pandemic and the then swine influenza virus were closely related and the latter strain was believed to have originated from the human strain. Presence of neutralizing antibodies in swine herds against human strains in New Jersey in 1938 further strengthened this view. It is interesting to note that the human virus responsible for 1918 pandemic ceased to cause disease in man by 1925, whereas its swine variant continued to cause annual outbreaks in U.K.

The next evidence suggesting interspecies relationship between influenza viruses came from the fact that antibodies against A/Equi, influenza virus were found in the sera of older persons. About 45% of the

persons, born between 1889 and 1895, possessed antibodies against HA and NA antigens of A/Equi 2/Milford/2/63 strain. The sera used were collected in 1957 and 1958, i.e., approximately 6 years before the first known prevalence of A/Equi 2 virus. J. L. McQueen of the School of Public Health, University of Michigan, in 1965 suggested that a virus closely related to 1963 equine strain (A/Equi 2/63) was responsible for the episode in man in 1889. This virus perhaps entered in human population between 1889 and 1895 and disappeared from human population by 1900.

It is now suggested that the Hong Kong human influenza virus did not evolve by mutation from a pre-existing human strain. Possibly it arose from a mixed infection in a mammal or bird of an animal influenza virus and a human Type A Asian strain. As such, animals besides serving as a source of antigenic variants, could play an important role in human diseases by serving as a reservoir for influenza virus strains which may be reintroduced into human population when the general immunity wanes.

#### Recombination in influenza virus

Recombination means sharing of genetic material between two strains of virus. Recombination within type A and B strains has been demonstrated but it does not occur between type A and B. Influenza virus has a segmented genome (Fig. 2), consisting at least 7 pieces of single-stranded RNA. The segmentation of genome facilitates reassortment of the genome in the event of a mixed infection with different strains.

An interesting phenomenon is the rapid and universal replacement of the strain of influenza virus prevalent at particular time by the strain that succeeds it. In addition to the examples cited above for 1889 and 1918 pandemic strains, the A0 strain and A1 strain virtually disappeared when subtype A1 and A2 spread around the

world during the year 1946-47 and 1957-58, respectively.

#### Immunity

Acquired immunity to a given strain is adequate for 1 to 2 years after natural disease. The infection induces antibodies against all the antigens of virus (NP, NA and HA). However, from protection point of view important antibodies are those directed against haemagglutinin and to a lesser extent, against neuraminidase antigen. The protection depends on the concentration of neutralizing secretory Immunoglobulin A-(IgA) in the respiratory mucosa. This specific antibody is in low concentration and is not able to prevent reinfection with the strain having slightly altered antigenic pattern, thus favouring the survival and spread of these strains leading to antigenic drift.

#### Prevention

Influenza vaccines are available in some countries. An ideal vaccine must incorporate the current strains of

influenza A and B. Influenza surveillance centres in over 50 countries enable early detection of new mutants, so that once a new strain is identified, it is distributed immediately to vaccine manufacturers around the world. The current vaccines consist of formalin inactivated chick embryo's allantois grown purified virus. The resulting inactivated vaccine is given subcutaneously or intramuscularly. The possibility of using live intranasal influenza vaccines, originally introduced by F. M. Burnet of Australia during World War II, is being re-examined. A recombinant between A2/Hong Kong/68 (H<sub>3</sub> N<sub>2</sub>) strain and a temperature sensitive mutant of the H<sub>3</sub> N<sub>2</sub> subtype has been found to be sufficiently attenuated to make a suitable vaccine.

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## Novel asthma related molecule synthesised

THE chemistry of the slow reacting substance of anaphylaxis (SRS), a biologically potent molecule well-known for its role in the lungs during asthma attack has remained elusive for the last forty years since its discovery. Recently SRS (also called *Leukotriene C*) has been synthesised jointly by the Harvard Professor E. J. Corey and his co-workers along with B.I. Samuelsson of Karolinska Institute, Stockholm (*J. Am. Chem. Soc.*, 102, 1436, 1980). The related substances are also called eicosanoids and belong to a family of long chain fatty acids of potential biological interest. SRS is generated and released by most cells which can co-aggregate in the lung tissues. The trigger for such a release is the arrival of the

antibodies of the IgE family, which in turn respond to the foreign substance called allergens. This cascade can cause dramatic effects which in worst cases can develop into anaphylactic shock and death. SRS is an important end product in the cascade. Corey predicts that the molecule can take part in other physiological activities under normal conditions. This unusual biochemical, where a peptide unit is linked covalently to a fatty acid, was reported incorrectly last year by Samuelsson. The short bioluminescent scheme is also being developed by the Harvard group which can utilise the well-known arachidonic acid.

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# SCIENCE FOR THE YOUNG

## Why we feel thirsty

**F**EELING of thirst, which forces one to obtain and drink water is stimulated by two factors; (i) lower extracellular volume (when the volume of fluid in extracellular space decreases), and (ii) a higher plasma osmolarity (the concentration of any solute in plasma per unit of total volume of plasma). Animals drink water to restore osmolarity of their plasma to normal; this is required when concentration of solutes is more (hypertonic). The animals stop drinking water, before the hypertonicity of plasma is really normalised. Ingested water would take some time before it is absorbed and becomes part of plasma, and only then it would be helpful to restore osmolarity. This is apparent from the behaviour of a dehydrated camel. It quickly drinks plenty of water and suddenly stops. These observations indicate the probable existence of a meter in pharyngeal area of gastrointestinal tract which controls the behavioral intake of water. The nature of this meter remains a mystery. In man, possibly because of psychic factors affecting fluid intake this 'metering ability' is not so precise as in animals.

There are two sources of body water; (i) metabolically produced from oxidation of carbohydrates, and

(ii) intake of water. Sites from which water is lost to the external environment are skin, lungs, gastrointestinal tract and kidneys. Under normal (physiological) conditions, water loss equals water gain and no net change in the volume of body water occurs. This is due to the regulatory mechanisms of water in the form of pituitary intake of water (thirst) and urinary loss. Other physiological processes which indirectly help water balance are primarily directed in other control mechanisms, for example, carbohydrate metabolism toward regulation of energy balance and sweating towards temperature regulation. Thirst mechanism is of great importance, because drinking of water is the only way to make up the water deficits in body. In human beings, it is also true that fluid-intake is often influenced more by habit and sociological factors than by the need to regulate water balance in the body. The selective control of urinary water loss is the major mechanism by which water volume is regulated.

Similar to food-intake, thirst is also one of the mechanisms controlled by hypothalamus. Hypothalamic lesions (destruction) abolish fluid-intake and electric stimulation induces drinking. In rat, 'thirst center' is in

the lateral hypothalamus anterior to the feeding centre in dog; it is dorsal hypothalamus, lateral to the paraventricular nuclei. Following natural or experimentally induced conditions, cause drinking in conscious animals :

(i) Increased osmotic pressure of the body fluids which stimulates the osmoreceptors of hypothalamus ;

(ii) Decrease in extracellular fluid volume ; and

(iii) Excessive bleeding due to injury or surgery.

The area in hypothalamus, which mediates thirst is situated closely to the regions responsible for the production of ADH (antidiuretic hormone or vasopressin). The receptors for ADH controlling reflexes are probably identical to those for thirst. Another vasopressin substance (Angiotension produced by kidneys) is also believed to stimulate thirst by direct effect on brain.

The sensation of thirst is inhibited either by direct damage to hypothalamus or by altered states of consciousness. Patients with certain brain damage stop drinking and dehydration results, if water balance is not restored intravenously.

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## Proper fraction as a sum of unit fractions

**I**T is said that about 4000 years ago the Egyptians had the knowledge of fractional members but they had no notation for proper fractions except for a few, such as  $\frac{2}{3}$ , which



they wrote as  $\frac{1}{n}$ . They had a notation for representing unit fractions only, which in our decimal notation system could be represented by writing '—' over the denominator concerned. So  $\frac{1}{2}$  could be written as  $\frac{1}{2}$ ;  $\frac{1}{5}$  as  $\frac{1}{5}$  and so on. In writing a proper fraction other than the ones mentioned above they would adopt the cumbersome process of writing it out as a sum of unit fractions. For example  $\frac{2}{5}$  which equals the sum of two unit fractions  $\frac{1}{3}$  and  $\frac{1}{15}$  would be written as  $\frac{1}{3} + \frac{1}{15}$ .

The British mathematician J. J. Sylvester (1814-1897) devised a simple technique for representing a proper fraction as a sum of unit fractions. Although Sylvester worked in the realm of higher mathematics, even comparatively trivial things in mathematics such as described below interested him. His interest in mathematics was so great that at one time when he was working as an actuary for a life insurance company he kept alive his interest in mathematics by taking a few private pupils. It is rather surprising to find that at that time Sylvester's most distinguished pupil was a young woman, Florence Nightingale, who in 1854 went out to the Crimean War and won universal acclaim as a nurse in a military hospital.

#### Sylvester's technique

Suppose  $\frac{5}{13}$  is to be converted into a sum of unit fractions. First subtract from  $\frac{5}{13}$  a unit fraction which is just less than  $\frac{5}{13}$ . It is easy to see that the unit fraction  $\frac{1}{3}$  is just less than  $\frac{5}{13}$ .

$$\text{Therefore } \frac{5}{13} - \frac{1}{3} = \frac{2}{39}$$

Now continue the process for the resulting proper fraction  $\frac{2}{39}$ . It will be seen that unit fraction  $\frac{1}{20}$  just falls short of  $\frac{2}{39}$ .

$$\text{Therefore } \frac{2}{39} - \frac{1}{20} = \frac{1}{780}$$

Combining these results

$$\frac{5}{13} = \frac{1}{3} + \frac{1}{20} + \frac{1}{780}$$

It can be proved that Sylvester's technique when applied to any proper fraction will not continue indefinitely. In other words, the last unit fraction will be obtained in a finite number of steps.

Sylvester's technique can be used to solve a similar problem, that of converting a proper fraction into a sum of unit fractions with odd numbers only as denominator. It has been found that in every case taken up for calculation with the help of electronic computers the process did not continue indefinitely, i.e., It stopped at a terminal unit fraction with an odd denominator after a finite number of steps. However, it has not been proved mathematically that this will always be so.

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## Science quiz

1. The control by light on growth, development and differentiation of a plant, independent of photosynthesis is :

- (a) Photomorphogenesis
- (b) Phytomorphogenesis
- (c) Phototropism

2. Study of light effects on living organisms constitute

- (a) Photoperiodism
- (b) Photobiology
- (c) Vernalisation

3. Exobiology refers to the

- (a) Study of terrestrial organisms
- (b) Study of exoderm
- (c) Study of life on other planets

4. Photomorphogenic pigment in plants is

- (a) Phytochrome system
- (b) Chalcone pigments
- (c) Chlorophyll

5. The physiological active form of phytochrome is

- (a) P 660
- (b) P 730
- (c) Mixture of both

6. All living cells of a particular plant, except perhaps one of the following, contain the complete genome

characteristic of that plant

- (a) Xylem cells
- (b) Sieve tube elements
- (c) Meristem cells

7. Single stranded DNA is present in

- (a) T M V
- (b) Salmonella
- (c)  $\phi$  X 174

8. DNA-histone complex can be removed from the chromosome by treatment with

- (a) 6 M NaCl +  $\text{Mg}(\text{OH})_2$
- (b) 1 M NaCl
- (c) Not separable

9. Histone occupies the major grooves of DNA at an angle of

- (a)  $45^\circ$
- (b)  $90^\circ$
- (c)  $30^\circ$  to the helix axis

10. The phenomenon of "low temperature promotion of flowering" is

- (a) Stratification
- (b) Impaction
- (c) Vernalisation

CHINTAMANI D. ATREYA  
ASHA VARMA  
Calcutta

## Brain teasers

### 1. Join the points

Twenty two points are shown in Fig. 1. Join these points so as to form three triangles. There must be a point inside every triangle.

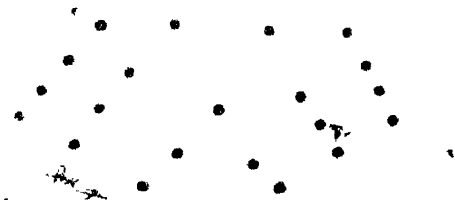


Fig. 1

### 2. The clever carpenter

Carpenter Ram Dulal had to construct a table 1.5 m square from the odd-shaped board shown in Fig. 2. He did it in two sawings. Can you too do the same?

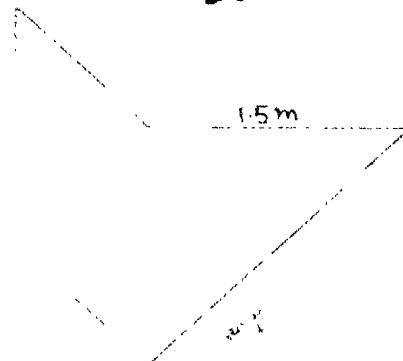


Fig. 2

### 3. Marriage

Nargis, Namita and Niharika will marry the three men named below. What are the names and professions of the husbands of the three girls if :

1. Kamal Kishore is a lawyer.
2. Namita is not engaged to the engineer.

3. The doctor's future wife is not Niharika.

4. Krishna Kant is engaged to Nargis.

5. Kalp Nath is the engineer.

### 4. The scrambled labels

You are given three boxes which are exactly identical in their external appearance. The first box contains two gold coins, the second contains two silver coins, and the third contains a silver and a gold coin. The boxes were originally labelled according to the contents of the box (e.g., the box containing two gold coins was labelled GG) but a mischievous boy has scrambled the labels on the boxes so that each box is now incorrectly labelled. You are required to identify the boxes by drawing one coin at a time out of any box without looking inside. What is the least number of drawings needed to do this?

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(See page 369 for answers)

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## FOR HER

### Menstruation— mechanism and disorders

**M**ENSTRUATION is a discharge of blood from vagina at more or less regular intervals throughout the child-bearing period of a woman's life. Each month, the womb (uterus) prepares itself for pregnancy by undergoing changes in its lining. If a fertilized egg fails to implant in the wall of the uterus, the lining of the uterus disintegrates and is discharged in the form of the menstrual fluid. Menstruation, physiologically speaking, is a direct manifestation of the marked hormonal changes, particularly of the sex hormones, in the ovary.

Human menstrual cycle is of 27-30 days. However, its duration varies and some women may develop a cycle with intervals of 21, 30, 35 or even 40 days. Only in 10 to 15 per cent cases the duration is exactly of 28 days. After the menarche, and in pre-menopausal age, women often experience menstrual irregularities as they do after child birth. The human

menstrual cycle is subject to many other factors, even to abrupt changes in climate. Other factors like disease, indisposition, malnutrition, passions or varied tensions may also shorten or lengthen it. The menstrual bleeding normally occurs for 4-5 days, but it may be as brief as one day or as long as 7-8 days. The important consideration is not duration of the cycle, but deviation from the usual duration and pattern.

Normally, menstruation starts among girls between 11 and 18 years. In rare cases, it may commence earlier than 11th year or is delayed upto 16 years. The commencement and cessation of menstrual cycle in the human female is dependent upon various factors, e.g., climate, race, general health and heredity. Normally in temperate climates, menstruation starts somewhat earlier—girls falling in the age-group of 13-15 years usually start menstruating in the warm climates, whereas in colder regions it may not start even at 17 or 18 years. If this important physiological phenomenon does not start at 16 years, medical help should be sought because too much delay implies deficient endocrinal functioning and, if untreated, may initiate sterility in the female.

Menstruation marks the entry of a girl into puberty—the age of great hormonal and psychic adjustments. It, in fact, is a step forward and marks entrance into womanhood—the fertile period of the human female. Menstruation ceases by the time a woman reaches 45 to 50 years, and the phase which follows is popularly known as menopause. The duration of the cycle, the duration of actual bleeding period and other menstrual characteristics are highly variable not only in different geographical regions or among different races, but also in different individuals of the same community. Hereditary factors have also been said to be involved inasmuch as menstrual peculiarities are so often

shared between the mother and her daughters. In those individuals among whom menstruation starts early, its cessation is also normally delayed.

The normal menstrual cycles are generally quite regular, but occasionally missed or irregular periods usually have no serious significance. They are frequent under psychological or physical stress. Gross menstrual irregularities like prolonged menstrual bleeding and persistent amenorrhea, however, warrant clinical investigation. Usually, however, a marked irregularity is associated, and rightly too, with decreased fertility. Though the significance of irregular menstrual bleeding varies with the type of irregularity, the common causes of irregular menstruation are: (i) infection in the uterus or even elsewhere in the female genital tract, (ii) presence of a benign or malignant tumor in the uterus or ovary, and (iii) an endocrine imbalance.

The human female has a pair of ovaries, the female gonads, which produce the ova or eggs. These cells are contained within follicles. There are approximately 400,000 follicles in the two human ovaries at the time of birth, but only 300 to 400 eventually mature and liberate the germ cells, most of which degenerate either as such, or after some degree of development. The number of follicles and, therefore, of ova is predetermined and fixed at birth, after which it does not change.

Each month, one of the ovaries responds to the influence of the pituitary hormone, called FSH, the follicle-stimulating hormone which, in turn, stimulates the growth of an ovarian follicle, which in turn secretes another hormone, called estrogen. In women, usually only one ovum reaches maturity during each cycle. Occasionally, however, if more eggs than one are released in a month, they usually degenerate before they are fully mature. Another pituitary hormone, viz., the lutenizing hormone (LH), causes

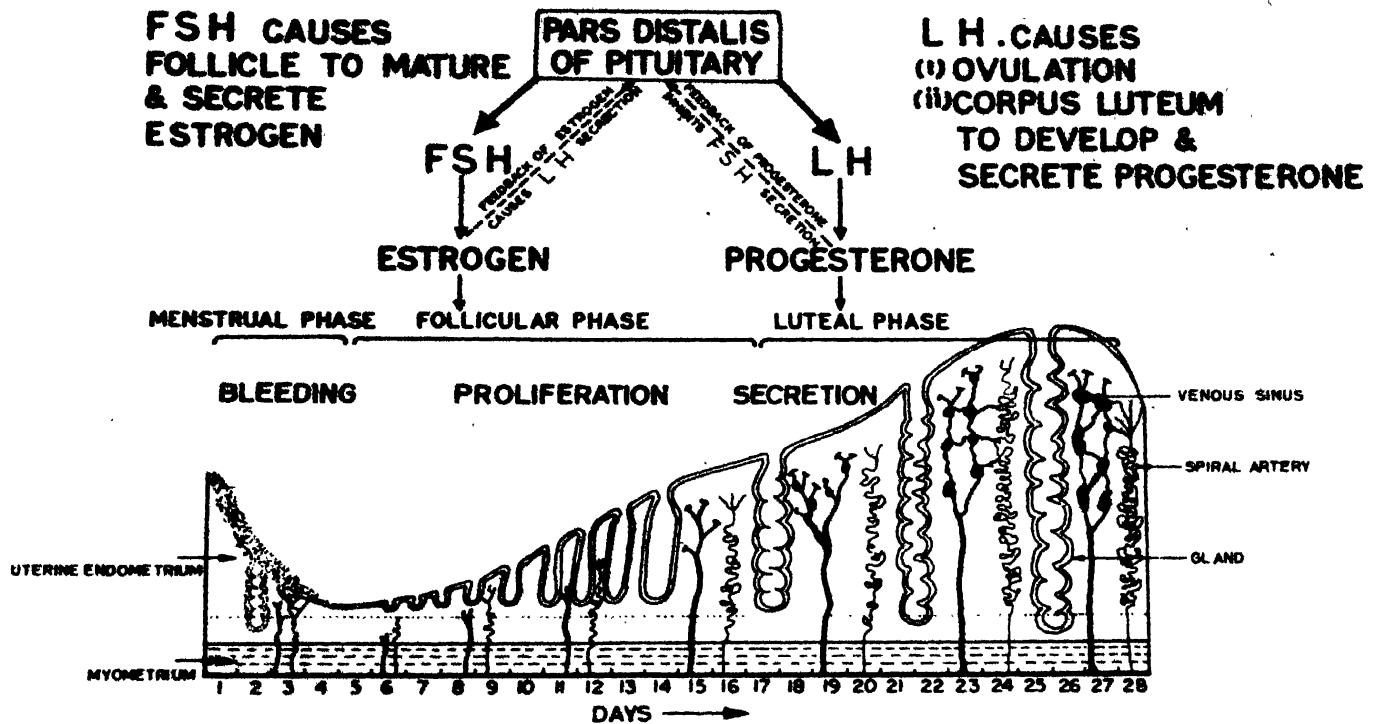


Fig. 1. Human menstrual cycle

the mature follicle to rupture and release an egg, and the remnants of the follicle are transformed into corpus luteum which secretes progesterone and estrogen. If, however, the egg is not fertilized, the corpus luteum persists for about nine days and then degenerates. The FSH is again secreted and the cycle restarts.

Based on these hormonal changes, the menstrual cycle can be divided into 3 phases. The day the menstrual flow begins is regarded the first day of the cycle because this is the date which can be determined with certainty. Most commonly, the menstrual phase lasts for four days, but periods of a day shorter or a day longer are common. During the next five or six days, endometrium—the lining of the uterus, gradually thickens under the influence of the estrogen. Meanwhile, in the ovary, the follicle grows and produces estrogen. This is called estrogenic phase. The last day of this

phase cannot be precisely determined because of the variability of the time of ovulation, i.e., release of ovum from follicle. Ovulation generally occurs between the 8th day and the 20th day and rarely before or after this period. The changes occurring in the endometrium during this phase are mainly under the influence of progesterone and, hence, this phase is called progestational phase. This phase starts after ovulation. It is after the release of the ovum that corpus luteum is formed. During this period, endometrium reaches a thickness of about  $1\frac{1}{2}$  cm.

About 24 days after the beginning of the monthly cycle, the corpus luteum starts degenerating and its hormonal secretion virtually ceases. Deprived of this hormonal support, the thick and succulent endometrium, which was studded with many microscopic glands and had unusually a rich blood-supply, starts disintegrating. This occurs as a result of the depleted blood-supply, which,

in turn, is associated with a lowered content of ovarian hormones in the circulating blood. Blood and desquamated endometrial remnants pass out through the cervix and the vagina as menstrual discharge. Rhythmic contractions of the muscular wall of the uterus facilitate gradual expulsion of the discharge. The physiological phenomenon by which the uterus is virtually denuded of its lining may, in certain cases, be somewhat painful. A day or more before the external flow has ended, the process of uterine repair is well under way.

The normal menstrual blood is pink to dark red. The total amount of the menstrual discharge varies from person to person and widely ranges from 50 ml to as much as 150 ml, which too is not rated abnormal. This fluid consists of blood and cellular debris from the endometrium and, characteristically, it does not clot and is odourless. The menstrual discharge on the first day is meagre, becoming more profuse during the

subsequent one or two days and then gradually diminishes. Blood forms 1/2 or 2/3 of the total discharge. The monthly loss of a sizeable quantity of blood from a woman's body necessitates a proper replenishment process which, in turn, requires an efficient supply of proper nutrients, particularly iron, without which anaemia ensues. Special invigorating tonics are recommended by doctors to compensate for the loss of blood and tissue from the body, especially in those cases where the menstrual discharge is heavy.

Sometimes, however, a monthly menstrual cycle is not accompanied with the shedding of an ovum. The follicle develops but instead of ovulating it regresses. Such ovulatory (devoid of ovulation) cycles are particularly common among young girls who have just entered puberty. Such menstrual cycles are a frequent cause or, at least, manifestation of infertility in adult women. It is difficult to determine such unproductive cycles, because menstrual flow occurs anyway.

Menstrual cycle is normally interrupted during pregnancy. If it is interrupted otherwise, it is definitely a physiological abnormality and warrants medical advice. Cessation of the menstrual cycle is one of the earliest signs of conception.

Throughout the menstrual cycle, there are concomitant cyclic changes in the secondary sex organs also. Some most striking changes occur in the endometrium under the influence of the ovarian estrogen. The endometrium rapidly grows; its thickness becomes the maximum at the time of ovulation. Blood supply is also increased owing to the proliferation of the basal blood vessels. But when the levels of estrogen and progesterone decrease, there is the kinking of spiral blood vessels. The blood-flow decreases which, in turn, results in uterine

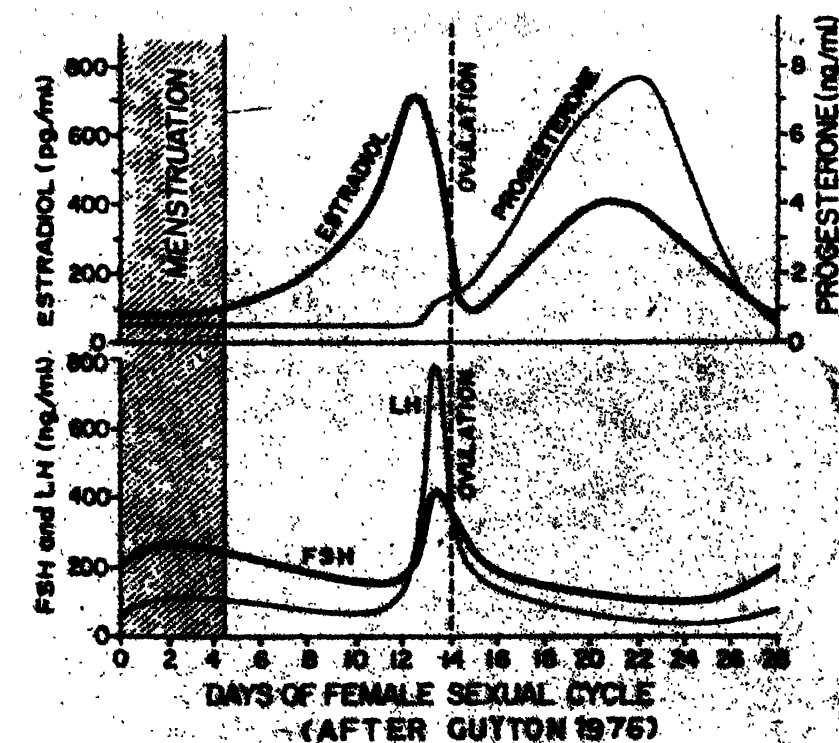


Fig. 2

infarction and facilitates denudation of the endometrium. As the endometrium is shed, bleeding from the remnants of arterioles occurs, hence the menstrual discharge.

Cyclic changes occur in the vagina also. Under the influence of estrogen, the vaginal mucosa becomes thicker. Breasts also undergo cyclic changes—they tend to enlarge pre-menstrually and often become tender. The enlargement is largely due to an accumulation of fluid which increases volume of the breasts. A slight swelling of the face and neck is also frequently observed.

#### Menstrual disorders

The absence of menstrual flow after the reproductive function has actually begun is called amenorrhea. This is normal during pregnancy and in the early months of lactation. Environ-

mental amenorrhea is developed by many women when they change their mode of life, e.g., shifting from one neighbourhood to another may cause amenorrhea. Girls often develop amenorrhea during examination. A journey overseas sometimes leads to sudden amenorrhea. Emotional disturbances may also interrupt menstrual cycle. Sudden changes in body-weight are frequently accompanied with amenorrhea. Some other pathological conditions may result in amenorrhea, e.g., tuberculosis, in which amenorrhea is the body's economy mechanism to save the patient's strength.

Too much or too frequent losses of blood may be due to glandular disturbance which should be corrected by a qualified physician. Such conditions may also involve the presence of a tumour or inflammation in the uterus. These conditions, if established, need the attention of a gynaecologist. A too

meagre menstrual flow also needs the help of a clinician. Clinically painful menstruation is termed dysmenorrhea. It may be caused by a faulty position of the uterus or as a result of uterine inflammation or may also suggest the presence of a tumour, but is most frequently due to pain in the nerves near the mouth of the uterus and can be relieved with certain routine analgesics, viz., aspirin, paracetamol and analgin. Unless there is some medical or surgical reasons for pain, menstruation should at the most be 'comfortably painful'. Many women experience no particular discomfort and their regular activities are not at all hampered. Exercise is recommended for obviating menstrual discomfort.

Some nervous imbalance during menstruation is commonly reported. Disturbance in sleep during the menstrual period is frequently experienced. The incidence of fatigue and headache during premenstrual and menstrual period is high. Depression is also not uncommon during such phases. The basic metabolic rate (BMB) and the temperature fall slightly during the menstrual period. Skin secretions and the characteristics of saliva also change and the capillary vessels of the skin bleed more readily.

Length of menstrual cycle is the difference of two dates—the onset of the previous, and the onset of the recent menstrual bleeding. The day of the commencement of bleeding is called day 1. Since the hour of the onset of the bleeding is not considered, the length of the menstrual cycle carries a methodological error of 1 day. Theoretically, the postmenstrual phase is the interval in days between the date of the preceding menstruation and the date of the following ovulation. Similarly, the premenstrual phase is the interval from the date of ovulation

to the date of the succeeding menstruation.

## Safe period for contraception

Abstinence around the time of ovulation can be a widely used method of natural contraception. The success of this method depends not only on a high degree of motivation and of intelligent understanding of the mechanisms of ovulation but also on a regular menstrual cycle and a reliable means of dating the time of ovulation. All these conditions are difficult to accomplish, or even to comprehend, especially in our country where illiteracy is rampant and hence our inability to exploit this natural way of contraception. Among women, with absolutely regular 28 day cycles, ovulation occurs on about the fourteenth day but very few women show such a precise regularity. While a woman, who has a regular 28 day cycle, generally ovulates at about the same time, some women may occasionally ovulate at an unusual time, particularly, if a cycle is irregular. Another reason for the failure of this method is the difficulty of precisely predicting the time at which the ovulation occurs. The time of ovulation is more closely related to the onset of the next menstrual period than it is to the end of the last one. For women who ovulate at an unusual time, the regular use of basal body-temperature charts can be of considerable advantage. If these women have a characteristic biphasic temperature pattern, they can be taught to recognize the temperature change associated with ovulation. Some women do experience a slight pain and even a meagre vaginal bleeding midway between the menstrual periods. This is believed to be a consequence of the rupturing of the ovarian follicle.

However, only some women experience these apparent manifestations, and even they do not do so consistently.

The examination of the vaginal mucus can also give us an indication about the time of the ovulation. If any reliable means can be found out to know the exact time of ovulation, the safe period can be precisely determined considering that the spermatozoa do not remain alive for more than 48-72 hours in the female genital tract and, further, that the ovum is fertilizable for not more than 1-2 days after it is released from the ovary. When the menstrual cycle is of 28 days, abstinence from 9-16 days of the menstrual cycle can be a good, safe, natural and effective method of contraception.

Many researchers have attempted to study the human sexual behaviour during different phases of menstrual cycle. Many married couples were surveyed and were asked to correlate sexual desire, behaviour and occurrence of orgasm with different phases of menstrual cycle. No clear picture seems to emerge except that conclusions drawn from such surveys do not confirm earlier beliefs; hardly any relationship could be established between the behaviour, orgasm and sexual urge, and the different stages of the menstrual cycle. However, some tendency was recorded for an increased frequency of sexual intercourse during the late follicular phase. Many individuals avoid sexual intercourse during the menstrual periods for hygienic or religious or ethical considerations.

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# Science in Industry

## NML-PM2 a versatile alloy conductor

**A**LTHOUGH aluminium is being used for electrical transmission for over the last three decades, until recently it was not accepted as a universal conductor of electricity. This was because the conventional electric grade aluminium (one not purposefully alloyed and having a purity of not less than 99.5 % aluminium with minimal amounts of titanium and vanadium) lacks ductility and strength and therefore it cannot be drawn into fine wires in modern high speed wire drawing mills without frequent breakages. Further, despite the advent of machines capable of cold pressure welding, the fact that the jointing procedures of aluminium wires were nearly not as simple as that of copper, and the extensive cold flow occurring at cold pressure joints (the crimp joints) decreased the acceptability of aluminium as a universal conductor of electricity. Even its use in the steel reinforced conductors (the ACSR) for overhead transmission of electri-

city met with considerable opposition on account of the lack of adequate corrosion resistance in marine and industrial atmospheres.

Against this background, a research and development programme was initiated at the National Metallurgical Laboratory about 15 years back. The aim of the programme was to develop an alloyed version of electric grade aluminium which is capable of developing electrical conductivity as high, if not higher, as in the conventional electric grade aluminium along with a combination of strength and ductility which would make it possible to be drawn into fine wires without breakages.

As a result of sustained experimentation, an electric grade aluminium alloy, called NML-PM2, was developed which offered a combination of properties which the engineers were long looking in aluminium. These were :

(a) high electrical conductivity, i.e., alloy additions should not sacrifice conductivity over gain in strength and ductility; (b) combination of mechanical properties, of strength and ductility to make aluminium amenable to the modern wire-drawing machines; (c) increased resistance to cold flow which is metallurgically obtained through higher creep strength, and (d) higher resistance to corrosion.

NML-PM2 offers these properties by ensuring precipitation of the deliberately added alloying elements through important control in the thermo-mechanical processing of the wires.

An important feature of the R & D work was that it integrated itself with the industrial conditions of processing and product development in the very early stages and that industry offered its facilities without any inhibition. Although from laboratory point of view, a number of alloys showed promise, the one designated as NML-PM2 emerged as the natural choice of technological considerations.

So far, four industrial units at Calcutta, Hyderabad, Delhi and Satna have obtained the technology through the National Research and Development Corporation. The fact that the four industrial licencees were spread over a 4-5 year period, proved that the industry was fully satisfied with the claims of NML-PM2 offering itself not only as a better alternative to the conventional electric grade aluminium but also as a substitute of copper in areas where aluminium did not hitherto make an entry.

Intensive product evaluation of the new alloy was carried out in collaboration with several R & D organisations and industrial establishments. As a result, the Indian Standards Institution have included NML-PM2 in the standards specifications IS 5484-1978 as additional grade of EC aluminium (grade 3).

Significantly, the first field evaluation trials for NML-PM2 were in areas of import substitution, for example, in telecommunication cables. 20-, 50- and 100-pair dry core tele-cables have been successfully produced from NML-PM2 in collaboration with Hindustan Cables Factory and found to meet the rigid specifications laid down by the P & T Department. After evaluation at the Tele-communication Research Centre, these cables were installed in Delhi about 5 years ago and are reported to be giving performance equivalent to those from copper. Techniques of crimp jointing are fully developed and commercially available in the United Kingdom and the U. S. A. There is no reason, therefore, to continue the import of copper for telecommunication purposes specially when industrially advanced countries are also finding it useful to substitute the usage of copper by aluminium alloy. Let not the doctrine of recycling of scrap of copper available in the P & T Department delay the introduction of new technology in India.

Stability of the joints over long periods is an important virtue of the

NML-PM2 cables—whether for telecommunication, railway coach wiring or flexible welding cables or even for house wiring applications. The stability of joints from NML-PM2 was evaluated by a leading laboratory in the U. S. A. and found to meet the rigid specifications of the Underwriters' Laboratory admirably. In the domestic arena the Railway Research Design & Standards Organization (RDSO) and the Integral Coach Factory have approved the use of NML-PM2 PVC insulated cables as a superior alternative to cables made from unalloyed electric grade aluminium. NML-PM2 wired passenger coaches are now in regular service with the Railways. RDSO is now engaged in a countrywide evaluation of the enamelled NML-PM2 fine wires as a possible substitute of copper in signal relays.

There was a time when inadequate performance of the 400 amp welding cables made from aluminium had reached such levels of frustration that many organisations were almost on the point of revoking their decision on substitution. But trial use of the NML-PM2 aluminium alloy welding cables restored their confidence in the import substitution programmes. In this respect, the strategy adopted by NML to introduce NML-PM2 to users through products paid divi-

dends. The NML got several thousand metres of 400 ampere welding cables manufactured at industrial units and introduced in the industry through supply of experimental lengths at cost. Leading engineering organisations have now started including NML-PM2 in their plant specifications.

It is regarded that the use of NML-PM2 overhead conductors with or without steel reinforcement, offers a possibility of reducing the loss of power in transmission through better performance. It is noteworthy that the Gujarat State Electricity Board (GSEB) in association with the Rural Electrification Corporation (REC) have installed NML-PM2 overhead lines for a few hundred kilometres along the coastal regions of the state. The results of monitoring over more than a year presented by the G. S. E. B. at the last R. E. C. Seminar in New Delhi indicated improved performance. The Karnataka and the Kerala State Electricity Boards are also considering installation of NML-PM2 lines. For the extra-high voltage grid, now under installation the use of NML-PM2 in place of conventional aluminium should take it an ideal material merely on account of the superiority of joint performance.

The use of annealed NML-PM2 conductor with steel reinforcement is

now being advocated as this would further reduce the power losses in transmission through improved conductivity besides the increased stability of the compression joints, and better corrosion resistance. It is noteworthy that the G. S. E. B. and the R.E.C. have again pioneered the use of the concept and 30 km-long conductors have been processed in Delhi for supply to G. S. E. B. for installation in the Kodinar Rural Electric Cooperative region.

In view of the growing imports of copper, and the resources availability of aluminium, it is hoped that the efforts of the NML team to develop aluminium alloys for the grooved contact and the catenary wires used in the railway electrification programmes would be as successful as PM2. It is gratifying from a national point of view that such spirit of collaboration has been assiduously built up by NML team with the RDSO. The RDSO has already put up a trial span of catenary near Tundla from one of the NML alloys (NML-PM53) for field evaluation.

RAJENDRA KUMAR  
Scientist

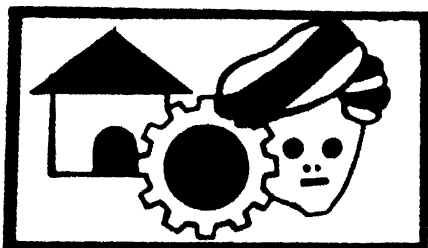
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National Metallurgical Lab.  
Jamshedpur

## TICK-BORNE DISEASES (Continued from page 385)

### Further reading

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## TECHNOLOGY FOR VILLAGES

### Charcoal aids water decontamination

CFTRI's central Food and Technological Research Institute, Mysore studies have established that wood charcoal which has been traditionally used for purification of water can also be successfully used for removal of certain pesticide residues from water. The decontaminated water so obtained can be rendered free of bacteria by treating with an antibacterial agent.

The particle size of wood charcoal is a crucial factor in the removal of pesticide residues from water, and hence this has been determined. Residues of 20 pesticides including those of BHC, DDT, Dieldrin, Malathion, Methyl Parathion, Chlordane, Endosulfan and Phosphonidon have been removed during studies using wood charcoal powder.

A percolator unit has been evolved by the Institute for decontamination of drinking water from pesticides and bacteria in households. This unit can be scaled up suitably for use in restaurants and hospitals.

## Industrial alcohol from Mahua flowers

CFTRI prepared a feasibility report on the manufacture of industrial alcohol from *Mahua* flower of Gujarat at the request of the Gujarat State Forest Development Corporation Limited.

The products that could be made from *Mahua* flower include potable alcohol, rectified spirit, baker's yeast, vinegar and concentrated sugar syrup. Costwise, the rectified spirit from *Mahua* flower will not be economical as compared to the product prepared from molasses unless the raw material cost is brought down and the byproducts are gainfully utilised. While *Mahua* flower costs about Rs. 600/- per tonne, molasses, with the same sugar content, costs only about Rs. 60 per tonne. The availability of molasses will, however, depend

on sugarcane production which is subject to variation. To be economically viable, the minimum capacity of the plant for manufacture of rectified spirit should be 20,000 to 30,000 litres per day. Since the available quantum of flowers ranges between 100,000 and 150,000 quintals, the suggested capacity of the manufacturing unit is 100,000 quintals.

The procedure for and cost involved in preparing *Mahua* syrup have been worked out by CFTRI. The dried pomace, discarded after preparing the syrup, could perhaps be used as an ingredient in animal feed formulation.

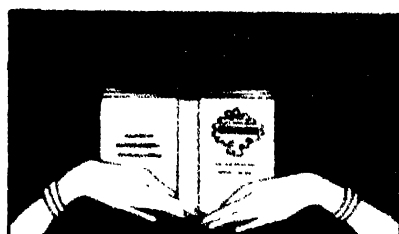
In view of the energy crisis, production of industrial alcohol from a renewable source like *Mahua* will assume importance.

## Vitamin E from wheat germ

CFTRI has standardised a process for extraction of oil from wheat germ and for producing vitamin E concentrate from the oil; the know-how has been given to a private firm who sponsored this project.

The germ which forms 2.5 to 3.6 per cent of wheat grain contains about 50 mg of vitamin E per 100 g of germ, and 6.7 to 9 per cent oil. This valuable source of nutrient is usually not available for fruitful

human use as during wheat milling it gets mixed with the bran which is mainly used as animal feed. Unwittingly, the nation is losing every year benefit of nearly 100,000 tonnes of wheat germ containing 50 tonnes of Vitamin E and 9,000 tonnes of oil that could be available from about 3.5 million tonnes of wheat annually milled by the organised roller milling industry.



## BOOK REVIEWS

**ATOMS OF HOPE** by Mohan Sundara Rajan, *Allied Publishers Pvt. Ltd.*, 13/14, Asaf Ali Road, New Delhi-110002, Pp. 156, Rs. 50.

THE story of atomic energy has been told and retold so often in the past that a new book on the subject evokes little interest. This is particularly so if the book is a 'cut-and-paste' work without much of continuity or coherence. In *Atoms of Hope*, Mohan Sundara Rajan attempts to present the whole gamut of the atomic energy question—from chain reaction, nuclear reactors and fuel cycles to "Bhabha's dream", self-reliance and Nuclear Non-Proliferation Treaty. But he leaves the basic questions unanswered. For instance, what is atomic energy, after all? Why do radioactive atoms behave in the way they do? Why doesn't a non-radioactive element undergo fission? These are some of the fundamental questions to which the book provides no answer.

There is casual mention of Einstein's famous equation  $E=mc^2$ , but the author fails to correlate it with the tremendous energy of nuclear fission (or fusion). Obviously he is not aware of the fact that the energy comes as a result of the *disappearance* of mass in the overall nuclear reaction. He does not mention it anywhere.

After going through the book one gets the impression that as long as it is a narrative such as the chapters on India's nuclear programme or Non-proliferation Treaty, the author has no difficulty. But wherever it comes to

explaining a scientific fact—be it the atomic structure or nuclear fission, he either takes recourse to unintelligible analogies or simply fails to explain anything at all!

Take, for example, his treatment of the atomic structure. Electrons, he says, "spin so rapidly that one can easily imagine them as spokes of a wheel (sic) moving at high speed" (p.4). I have yet to see a more distorted picturisation of the atom.

Or take the following para : "Certain atoms break up on their own. The radioactive atoms shoot out energy (sic), alpha particles and electrons. A small quantity of matter contains an enormous number of atoms. The energy available must be quite big, if only it can be released."

I wonder what such disjointed sentences explain. And the text is replete with such irrelevant and incoherent paragraphs that make the reading tedious.

Frequently one finds reference to events that are not described earlier. I shall cite just one instance. He says, "After Bohr arrived in the United States in 1939, the news about the Berlin development reached Fermi." (p. 7). But nothing is mentioned to explain what this 'Berlin development' was till four paras later, on the next page! Normally one expects the narration of an event first and a reference to it later.

The question of safety of nuclear power is discussed at length as is the future of India's nuclear programme. The Indian stand on the Nuclear Non-proliferation Treaty has also been explained well.

BIMAN BASU

**ALTERNATIVE SCIENCES** by Ashis Nandy, *Allied Publishers Pvt. Ltd.*, 13/14, Asaf Ali Road, New Delhi-110002, Pp. 155, Rs. 40.

THAT this book deals with the psychological study of two great

scientists that India gave to the world makes one, on the first glance, wonder what the title has to do with them. It is only after going through the book that one fully understands its implications. According to the author, who is a well known psychologist, the two Indian scientists, J. C. Bose and S. Ramanujan, provided two alternative ways of looking at science. By proving that plants and metals have life, Bose had experimentally shown that what is called the "Cosmic Unity" by the philosophers of the East was correct. By his enlightening discoveries Bose had shown the West that theirs was not the only way of looking at the world or science. By his ingenious mathematical creativity and discoveries (mostly re-discoveries) S. Ramanujan, on the other hand, showed the West what a person of his orthodox background could achieve without any brush with scientific culture. The book is therefore exclusively meant for historians of science, psychologists and social scientists. However, a layman would also find in it something of his interest in particular the explosive unpublished details of J. C. Bose's life.

Biographical details of both the scientists make good reading. The author gives in details their surroundings, the way each was brought up and the various influences of personalities, culture and religion that made them what they were. The most common thing between them was the influences of their mothers as well as their religious biases. It has been found that but for the influences of their wives in later part of life, the mothers played a major role in developing their personalities. On the other hand, their fathers differed. S. Ramanujan's father was a petty clerk who only wanted that his son should become a clerk and earn something. J. C. Bose's father, though a business man, always encouraged, from a distance, his son's activities. In fact, it is believed that the streak



J.C. Bose : a manipulator or a psychic case?

of innovativeness in Bose can easily be attributed to his father, who liked dabbling with gadgets and machinery. Besides these influences, how religion affected the scientists in doing what they did, the reviewer, frankly speaking, fails to understand because of psychic undertones and jargon, which only a competent psychologist can appreciate. Two things, however, appeared crystal clear to the reviewer.

The author has alleged that most of the research J. C. Bose did in his later part of his life was nothing but exaggeration. He has even claimed that Bose manipulated his experimental results to suit the needs of his times. However, nowhere has the author given concrete examples to prove his point. He has only given the reasons why he did so. In those pre-Independence times, the author says, Indians found in Bose a scientist who gave boost to not only their national pride then at a low ebb but also to their philosophy of cosmic unity. Bose therefore tried to live up to the expectations of his countrymen by making, as the author says, false claims. In case of Ramanujan, an altogether different psychology worked. Although many occult instances have been linked with his mathematical creati-

vity, "he was an artist who was satisfied if he could convince himself," which is aptly true of him.

Besides the author's racy style, one thing the reviewer especially appreciates is his boldness in smashing the aura created around J. C. Bose by many of his biographers. In this context he has no doubt been a crusader because we Indians have the habit of hero-worship. We kick a person until he is recognised by the West, and when once he is recognised we forget all his weaknesses!

DILIP M. SALVI

**INORGANIC CHEMISTRY CONCEPTS** by P. L. Soni and Mohan Katyal, *Sultan Chand & Sons*, 23, Daryaganj, New Delhi-110002, Pp. 229, Rs. 15.00.

**I**NORGANIC chemistry is not merely a descriptive science. It is a systematic subject rather than a collection of unrelated facts. Much of it may be explained and correlated in simple physical terms as has been done in this brief volume.

The book is divided into eight chapters, beginning with a brief introduction about what is chemistry. It then goes on to describe inorganic chemistry and its importance. The second and third chapters give the classical model and the modern picture of the structure of the atom. The next chapter deals with the classification of elements and their various physical properties like atomic radii, electronegativity, ionisation energy, etc. The theories of chemical bonding, both classical as well as the modern ones, viz., Valence Bond Theory, Molecular Orbital Theory and Linnert Double-Quarter Theory have been described well.

The seventh chapter deals with concepts of acids and bases on the

basis of Arrhenius, Brønsted-Lowry and Lewis theories. It also discusses hard and soft acids and bases (HSAB theory). In the last chapter, Standard Electrode Potentials are discussed.

The book is written in a compact and easy-to-understand language. The various sections are concise and the information up-to-date. At the end of each chapter, a list of selected reading is provided. Each chapter also carries a large number of problems to be solved by the students. They will surely help the readers assess their own understanding of the problem.

The book should prove useful to first year students of B.Sc. (Hons.) chemistry of Delhi and other universities.

SUBHASH C. HARI

**TEXT BOOK OF ALGEBRA, LEADERSHIP PROJECT COMMITTEE** (Mathematics) University of Bombay, *Tata McGraw Hill Publishing Company Ltd.*, 12/4, Asaf Ali Road, New Delhi-110002, Pp. 166, Rs. 15/-

**T**HE book has been brought out under the University leadership Project in Mathematics of Bombay University sponsored by University Grants Commission. The book gives introductory course in algebra meant for study in undergraduate classes of Indian University. It covers the whole spectrum of subject systematically and chapters are well graded. Starting from the treatment of integer and natural numbers, the book culminates at Matrix computations. Linear algebra and solution of simultaneous equations are given in detail. Chapter on Determinants as appended at the end adds to the usefulness of the book. Language is simple and direct and explanations are explicit. It is a good attempt indeed.

R. K. BHATNAGAR

**GYMNOSPERMS : A TREATISE** by O. P. Sharma, *Pragati Prakashan*, P. B. No. 62, Meerut-250001 (1980). Pp. 256, Rs. 15.30

THE book under review deals with the gymnosperms, a group of plants represented by living as well as fossil members. It is composed of 11 chapters. Chapter 1 deals with the introduction, general characters and affinities of gymnosperms. In Chapter 2, classification is discussed but, surprisingly, which classification is adopted in the book, is not mentioned. Chapters 3 to 5 and 7 deal with the fossil representative, while the rest with the living members. Each chapter

is provided with a bibliography at the end; it is, however, not complete and correct in some chapters. It would have been better if a general bibliography had been given so as to minimize unnecessary repetitions. The illustrations are good and well labelled but the photo-plates are of poor quality. A subject index followed by an author index is given in the end, which is a welcome addition. The book will serve the purpose of B.Sc. and B.Sc. (Hons.) students only. It is reasonably priced. The author should, however, have taken care in keeping consistency in the format and minimized the number of printing mistakes.

K. Y. KAVATHKAR

### Books received

1. **NATURE DAY AND NIGHT** by Richard Adams, *Penguin Overseas Ltd.*, 106 Eros Apartment, 56, Nehru Place New Delhi-110019, Pp. 108, £ 2.50
2. **EVER SINCE DARWIN** by Stephen Jay Gould, *Penguin Overseas Ltd.* (address as above), Pp. 285, £ 1.50
3. **MATHEMATICS**, Second level, by G. W. Allan and A. Hill, Hutchinson of London (Available from *B. I. Publications*, 359, Dr. D. N. Road, Bombay-400023), Pp. 310, £ 4.25

### SCIENCE SPECTRUM (Continued from page 106)

Table 1

Types of system	Types of micro-organisms involved
<i>(a) Asymbiotic, free living</i>	
1. Bacteria	Azotobacter, Bacillus, Clostridium, Desulfohalobium, Pseudomonas, Rhodospirillum and Azospirillum
2. Blue-green alga	Anabaena, Anabaenopsis, Aulosira, Calothrix, Nostoc and Cylinodrospira
3. Yeasts	Rhodotorula
<i>(b) Symbiotic</i>	
4. Root nodules of legumes	Rhizobium
5. Root nodules of non-legumes	Actinomyces

within the temperature range of 20°C-30°C.

Biological nitrogen fixation and its importance to soil fertility have been known since the early 1800s. Some biological systems are recognised which are capable of fixing atmospheric nitrogen (Table 1).

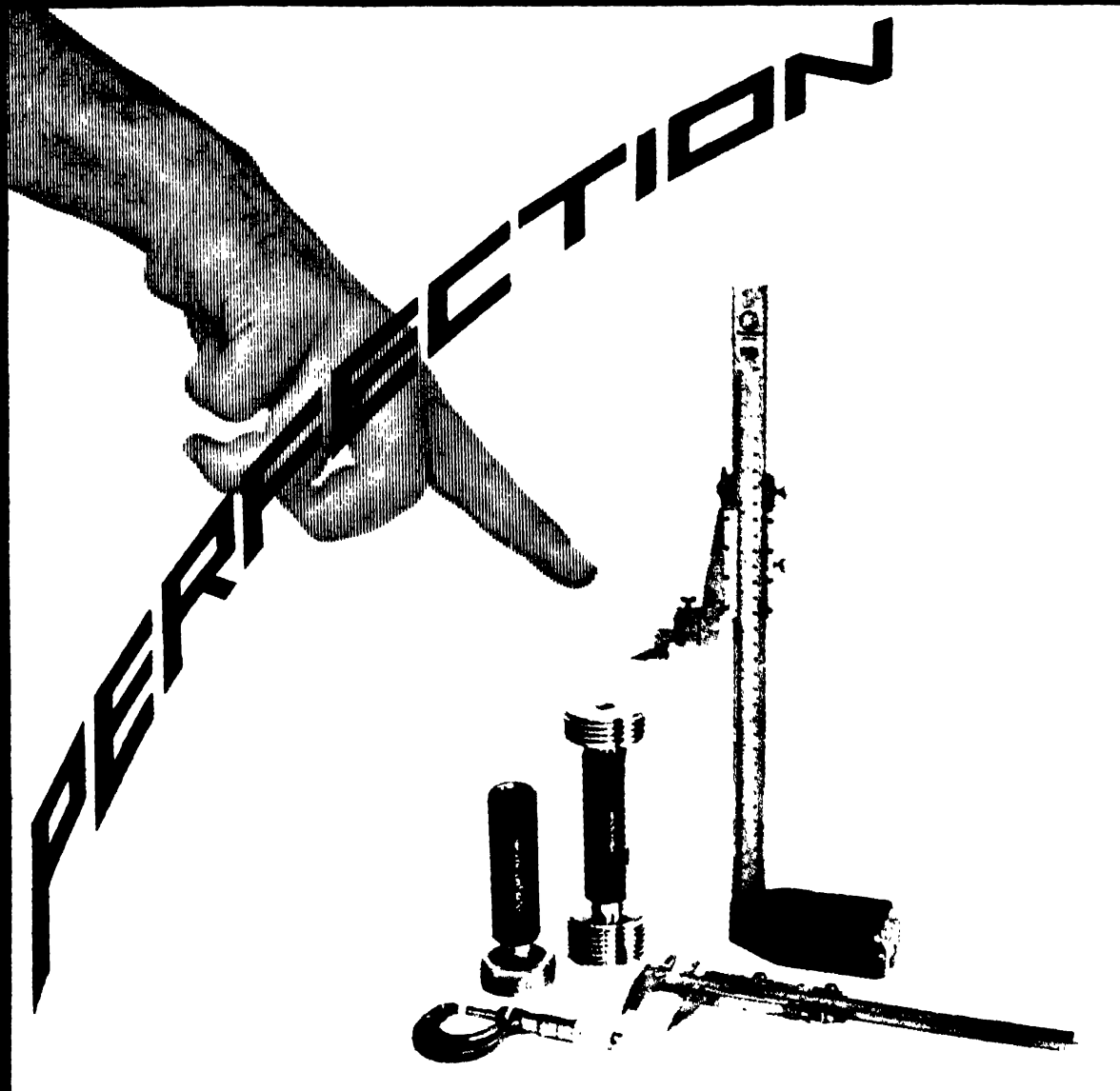
In developing countries like India where there is immediate need to rely increasingly on organic fertilization of soil, these biofertilizers play a role

in minimising dependence on inorganic nitrogenous fertilizers. The biofertilizers, otherwise called microbial inoculants, are preparations containing live or latent cells of efficient strains of nitrogen fixing micro-organisms used for seed or soil application. The main objective of applying inoculants is to increase the number of such micro-organisms in soils or rhizosphere and consequently improve the extent of micro-biologically fixed

nitrogen for plant growth. Application of biofertilizers in combination with organic nitrogenous fertilizers has a key role to play in the economic management of nitrogen needs of crops.

Bacteria and blue-green algae play a significant role in meeting the nitrogen needs of crops. The occurrence of nitrogen fixing micro-organisms such as Azospirillum within the plant parts of major economic plants and the symbiont *Anabaena azollae* within the equatorial fern are being recently tried in Indian agriculture. Man made inoculants are helping in the establishment of leguminous crops and also in increasing the production of protein rich food and fodder crops. Man made inoculants containing living cells of effective Rhizobium bacteria are commercially prepared and sold to farmers.

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